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A SHORT ACCOUNT OF INTERNATIONAL TELEGRAPH CONVENTIONS.

MOST of our readers are no doubt well acquainted with the successive steps taken by the various telegraph conventions which have met since 1865. Nevertheless a brief summary of the changes made in the Regulations of Telegraph administration, and the history of the gradual adoption of an uniform rate, may be of interest to many who have not followed the subject with close attention.

At the Paris Conference of 1865 the system of zones or countries on which rates had hitherto been based was suppressed. A uniform tariff for each country was adopted on the basis of 20-word messages with an additional charge at the rate of 50 per cent. for every additional 10 words. This tariff included terminal and transit charges, and applied to both European and extra-European traffic.

The Vienna Conference of 1868 made but little alteration to the existing regulations, excepting that messages with a minimum of 10 words were admitted for extra-European traffic.

At this conference, the principle was established in the International Regulations, that reduction of tariffs, permissible between the contracting States, should not be made with a view to competition, but in order to afford the public, at equal rates, as many routes as possible.

At the Conference held in Rome in 1872 the laws relating to tariffs were not altered, but the question of substituting a word rate for the existing message rate was discussed for the first time, and was admitted jointly with the minimum 10-word message for extra-European traffic.

The St. Petersburg Conference of 1875 definitively adopted the word rate for extra-European messages. The minimum 20-word message, as well as the minimum 10-word message, was in force for European traffic, but there was an evident tendency towards adopting the word rate also for this class of traffic.

Up to this time conventions emanating from the International Telegraph Conferences, as well as the regulations prescribed, and the tariffs adopted, by these conferences, were entirely the consequences of diplomatic procedure, and could only be modified by the actual representatives of the Governments. The Conference of St. Petersburg decided that the convention alone should continue to be of a diplomatic nature, and that the regulations and tariffs should be considered as merely administrative, and should be revised or altered by administrative conferences without the intervention of diplomatic agents.

The London Conference of 1879 introduced a thorough reform in the tariffs applied to the European *régime*. During the interval between the conferences of St. Petersburg and London the principle of the word rate had been vigorously advocated by France, and the various administrations had come to look upon it with favour. It already existed in the internal traffic of France and Germany, it was soon adopted in the communications between those countries, and many other States were introducing the word rate when the London Conference was held.

This conference definitively admitted the word rate in the European *régime* with a surtaxe of five words on each message, but France strongly opposed this surtaxe as it would be a means of complicating the collection of rates and the settlement of accounts. This opposition led the conference to decide that all States should be at liberty to fix their tariffs by private agreement, and that all stations should be allowed to apply the word rate pure and simple to the collection of tariffs, on condition that the change should not occasion a difference of more than one-fifteenth from the figures given in the tables accompanying the International Regulations.

The conference held at Berlin in 1885 could not overlook the confusion existing, due to the great diversity and variety of terminal and transit taxes levied by the various States. In France the terminal and transit taxes varied to the extent of 4, 6, 7, 8, 10, 11 and 12 centimes, while in Italy there were 12 different taxes, and in Greece no less than 13. In brief, the Berlin Conference finally adopted the following system for the regulation of traffic for all States in the European *régime*:

1. All States in the European *régime* to adopt one and the same elementary tax.
2. The terminal tax is fixed at 10 centimes.
3. The transit tax is fixed at 8 centimes.
4. The smaller States, viz., Belgium, Bosnia-Herzegovina, Bulgaria, Denmark, Greece, Luxembourg, Montenegro, Holland, Portugal, Roumania, Servia and Switzerland are to have a reduced terminal tax of 6½ centimes, and a transit tax of 4 centimes.
5. All States in the European *régime* may reduce their terminal taxes.
6. Russia and Turkey are allowed to charge higher terminal and transit taxes than above given.
7. A special transit tax may be charged on submarine cables.

The great advantage of the Berlin regulations lies in the suppression of the surtaxe of five words on European traffic, resulting in a benefit to the public of a reduction of about 25 per cent. on International rates not already altered by private agreement.

It was found impossible to unify the rates on submarine cables in the manner and to the extent adopted for the traffic between the various States; it was therefore considered reasonable to fix for each individual cable a surtaxe on messages passing over it.

In view of the feeling expressed by the Conference, the cable companies in general agreed to considerable reductions in their tariffs, both in the European and

extra-European *régimes*. The new regulations and tariffs will come into force on the 1st July, 1886.

We are indebted for much of the foregoing information to a report on the results of the Berlin Conference laid before the French Chamber of Deputies for its approval. In this report it was stated that the reduction in tariffs would entail a diminution in the French telegraph revenue of about 600,000 francs for the first year; on the other hand a large increase of traffic was to be expected from the reduced rates, judging by former experience. The lowering of rates in 1878 produced an increase of 199 per cent. in the French internal service, and the reduction of tariffs by the London Conference resulted in an increase of traffic to an enormous extent.

THE CABLE CONFERENCE.

THE International Conference for the protection of submarine cables assembled in Paris on the 12th inst., under the presidency of Mons. Freycinet, assisted by Mons. Granet, the Minister of Posts and Telegraphs. Twenty-four States were represented as follows :—

Argentine Confederation.—M. Paz, Argentine Minister in Paris.
Austro-Hungary.—Count Goluchowski, Counsellor of the Austro-Hungarian Embassy in Paris.
Belgium.—M. Leopold Orban, Director of Political Affairs at the Foreign Office in Brussels.
Brazil.—Baron d'Arinos, Brazilian Minister in Paris.
Costa Rica.—M. Leon Fernandez, Costa Rican Minister in Paris.
Denmark.—Count Moltke-Hvitfeldt, Danish Minister in Paris.
France.—M. Granet, Minister of Posts and Telegraphs; assisted by M. Clavery, Director of Affairs at the Foreign Office; M. Fribourg, Director in the Ministry of Posts and Telegraphs; M. Louis Renault, Professor of the Faculty in Law, Paris; Captain Chassériau, Commander French Navy; M. Raynaud, Telegraph Engineer.
Great Britain.—Mr. Kennedy, C.B., Foreign Office; Mr. Trevor, C.B., Board of Trade; Mr. Lamb, Post Office; Mr. Farnall, Foreign Office.
Greece.—M. Delyannis, Greek Minster in Paris.
Guatemala.—M. Goguel, Guatemalan Consul-General in Paris.
Holland.—Chevalier de Stuers, Minister of Holland in Paris.
Italy.—M. Salvatori, Inspector-General of Telegraphs.
Japan.—M. F. Marshall, Counsellor to the Japanese Legation.
Portugal.—M. d'Andrade Corvo, Portuguese Minister in Paris; M. de Brissac, Governor of Portuguese Congo.
Roumania.—M. Alecsandri, Roumanian Minister in Paris.
Russia.—Captain Alexeief, Commander Russian Navy.
Salvador.—M. Pector, Consul-General for Salvador in Paris.
Servia.—M. Marinovitch, Servian Minister in Paris.
Spain.—M. Albareda, Spanish Minister in Paris; M. Coromina y Marcellan, Chief of the International Telegraph Office; Captain Sanchez Acana, Commander Spanish Navy.
St. Domingo.—Baron Almeda, Minister of the Republic in Paris.
Sweden and Norway.—Count Charles Lœwenhaupt, Minister of Sweden and Norway in Paris.
Turkey.—Djemel-Bey, Chief Secretary of the Ottoman Embassy in Paris.
United States.—Mr. MacLane, United States Minister in Paris.
Uruguay.—Colonel Diaz, Uruguayan Minister in Paris.

The conference elected M. Feliz Granet as President, and M. d'Albareda as Vice-President.

The secretaries are: M. Lavollée, Consul-General of France, and M. Torin, Chief Secretary at the Ministry of Posts and Telegraphs. The assistant-secretaries are: M. Weillet-Dufriche, Chief Clerk at the Foreign Office, and M. Gérard, Secretary of the Technical Committee at the Ministry of Posts and Telegraphs.

Among the list of delegates we are glad to see the name of M. Raynaud. This gentleman really understands submarine telegraphy, and considering that the matter to be discussed relates exclusively to this subject, it seems a pity that among his numerous colleagues he will be unable to find a single one who has the slightest knowledge, from a practical point of view, of what submarine telegraphy really is.

We have carefully examined the list of delegates, and among these 35 gentlemen, there are probably four who understand a marine chart when they see it, there are probably five who could recognise a sample of submarine cable if laid before them, there are probably two who know what a submarine cable is composed of, and it is absolutely certain that there is only one who can appreciate the intrinsic value of submarine cables or estimate the compensation due for damage done.

Fortunately for the interests of cable proprietors (among whom English capitalists figure to the extent of over 90 per cent.), Messrs. Pender and Weaver, Sir James Anderson, and the Marquis of Tweeddale, have at great personal inconvenience gone to Paris, where, although there is small hope of their bringing direct influence to bear on the conference, it is expected that some benefit will result from their efforts in the lobby.

It will be remembered that the first conference was held in Paris in 1884, and an international convention was drawn up and signed on the 14th of March of the same year.

This convention was to have come into force on the 15th of January, 1886, but was postponed till the 1st of January, 1887.

It has been found, however, that several questions have still to be decided, owing to the fact that many States have not yet legislated on the subject, and that others have formulated laws and regulations entirely at variance with the spirit of the convention.

The English law on the subject shows, above all, the most serious divergence from the convention. The Bill passed by the English Parliament limited the responsibility, for damage done to cables, to a depth of 100 fathoms. The convention established the responsibility, without regard to depth of water or distance from land, of the persons engaged in laying a new cable for any damage done to a cable already existing. Germany, one of the contracting powers in 1884, has not sent a representative to Paris on this occasion, but she has declared, through her ambassador in Paris, that she agrees with France in condemning many of the alterations, made by certain States, to the original convention.

EBEL'S IMPROVEMENTS IN TELEPHONIC APPARATUS.

IN designing this instrument, writes Mr. Ebel, I have endeavoured to analyse and provide against the defects which are the cause of imperfect action in the existing types of telephones.

These effects are various, and their combinations have the effect, generally, of making the speech transmitted by them either inarticulate when loudness is an attribute, or weak when, by modification in their structure, articulation is improved. Principal among what I regard as the above-mentioned defects are the following :—

In the existing types of instruments the magnet generally exposes only a small portion of its surface to the action of the diaphragm, whose vibration at other parts than the small spot are, therefore, to a great extent ineffective; for the same reason the area of magnetic matter, and, consequently, the number of magnetic lines of force acted upon or affected by the diaphragm is small compared to the whole strength of the magnet. Thus much of the energy received from the air by the diaphragm is wasted, because means are not provided for its sufficient utilisation.

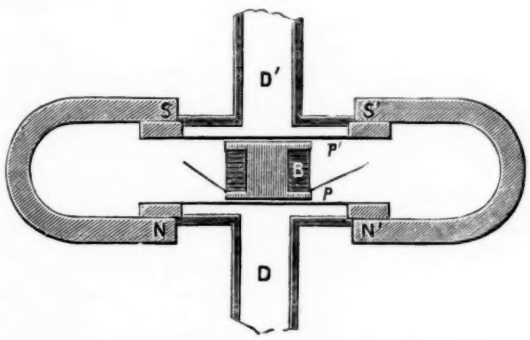
I propose to supply this want of magnet surface by magnetising the diaphragm itself, to utilise the opposite pole of the magnets, and also to intensify the field. I add another diaphragm and oppose it to the first; one or more receiving or transmitting coils are placed between these two diaphragms.

This combination permits the addition of as many more magnets round the circumference of the dia-

phragms as may in practice, and under varying circumstances, be found necessary. Under these conditions the diaphragms are strongly attracted towards each other, and a strongly excited magnetic field is formed between them, which is varied in intensity by any movement of the diaphragms; and as these are uniformly magnetised, vibration at any part of their surface is more equally effected.

Another important point which I have kept in view is the fact that we are all provided with two ears, and this has suggested to me not only that the telephone should be provided with two diaphragms, but that our heads should also be made as efficient receivers of sound as possible, by providing that that emitted by the telephone should be conveyed to both our ears instead of only to one, as is generally the case. For this purpose I would provide a flexible tube from each diaphragm.

In the fig., D and D are the two diaphragms supplied with two magnetic metal vibration plates, p and p_1. These vibration plates are strongly magnetised by the poles of magnets S′, N′, and S, N.



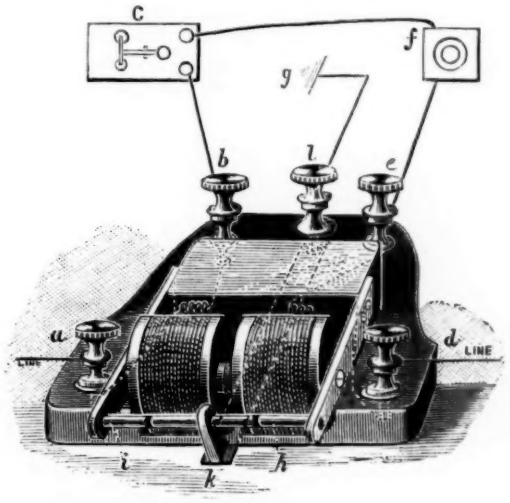
In the magnetic field produced by plates p and p_1, is placed the transmitting or receiving coil, B.

[Mr. Ebel has (no doubt quite unconsciously) in his invention actually done nothing more than combine several improvements in telephonic transmitters which were suggested or brought out several years ago. The use of a double diaphragm combined with a short bar electro-magnet, and the employment of double ear tubes, will be found suggested and minutely described in our Correspondence columns of about three years back by Mr. Strangways. Double ear tubes, it is, perhaps, unnecessary to say, are not novelties as Mr. Ebel seems to imagine, inasmuch as they are used in the Gower-Bell instrument. In the Phelps "Crown" telephone an arrangement of permanent magnets, such as that described by Mr. Ebel, was invented in the early days of telephony. The magnetisation of the diaphragm is a notable point in the Ader telephone. We may mention that the suggested employment of several electro-magnets to one diaphragm is a complete delusion; it has been again and again proved that no compound arrangement of the kind is any better than the simplest arrangement which has been devised.—EDS. ELEC. REV.]

LIGHTNING ARRESTERS.

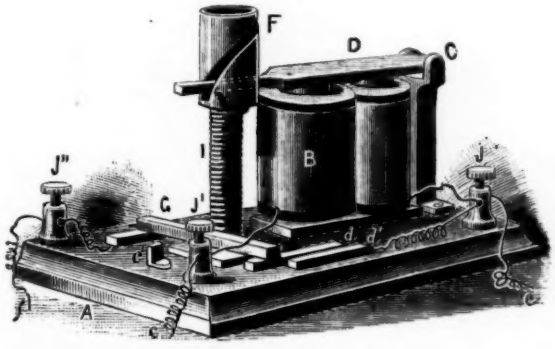
TWO forms of lightning arresters and automatic cut-outs were described in the columns of the *Scientific American* for the 8th inst., and these we reproduce below.

The first is that of Mr. P. P. Belt, of Columbus, Kansas, the illustration showing a simple device calculated for use in telegraph, telephone and other stations where electrical line instruments are used, one intended not to interfere with the ordinary working of the line, but which will ground the line when the electric current is so greatly increased as to abnormally affect the apparatus, as sometimes happens during thunder storms. The apparatus is mounted on a block, in the centre of which is a smaller block, from which project two metallic spring arms that support two electro-magnets wound with coarse, heavy wire, their pole pieces in the centre closely approaching, but not in contact with each other. The spring arms project beyond the magnets, and at their ends carry contact points, h, i, which project inward toward a central standard, k, which carries contacts in line and arranged to co-operate with the contacts, h, i. The standard, k, is in electric connection with the ground at g through the binding post, l. The line wire leads to the terminal, a, thence through the spring arm and magnet to the terminal, b, to the line instruments at the station, c, f, back to the terminal, e, through the coils of the other magnet to d, and on to the line. The magnets, being made of heavy, coarse wire, will not be appreciably affected by an ordinary current, but when they become heavily charged, will so attract each other that the contact points, h, i, are brought into electric connection with the contacts that extend from the central standard, k, thereby grounding the line.



BELT'S CUT-OUT AND LIGHTNING ARRESTER.

The second arrangement is for the purpose of affording an improved lightning arrester and automatic cut-out for dynamo-electric machines, the inventor being Mr. John Horen, of Omaha, Neb.



HOREN'S LIGHTNING ARRESTER.

When the current is working normally on the circuit, the armature, D, is drawn down to the bottom of the cam, F, turning the sleeve in opposition to the tension of the spring, I, and bringing the bar, G, into contact with the bar, d, of the lightning arrester. The

line wire, *e*, is connected with the terminals, J and J′, these posts being connected with the terminals of the magnet, B; and when the line wire is struck by lightning the current, in passing from *d′* to *d*, to reach the ground through the bar, G, and ground wire, *f*, forms an arc between *d′* and *d*, when the dynamo current will continue to pass the space between the base of the lightning arrester to the ground for an instant, and the diversion of the current allows the magnet to become demagnetised, thus releasing the armature, D, and removing the bar, G, from the bar, *d*, when the arc will be broken and the dynamo current follow its original path. This device also indicates, by its momentary action, if the lightning arrester is clogged with dust or any conductive material, so as to short circuit the dynamo and send the current to the ground instead of over the line.

COMPARISON OF LOCOMOTIVES, AUTOMOTORS AND TRAMCARS, WORKED BY STORED-UP ENERGY.

By A. RECKENZAUN.

THE mathematical reasoning, from the jurors' report on the Antwerp trials of mechanical traction for tramways, has a tendency to obscure the very point, at the outset, which in the end it intends to prove, viz., the superiority of automotive, or self-propelled cars, over those drawn by separate locomotives. The report says: "In calculating the weight, Q, of a locomotive which has to exert on the periphery of the driving wheel an effort, E, the adhesion must, first of all, be taken into account. In fact, if α be the co-efficient of adhesion in the case of a motor which is supposed to utilise the whole of its adhesion, the lower limit of the weight, Q, will be given by the formulæ

$$E = \alpha Q$$

$$Q = \frac{E}{\alpha},$$

This co-efficient of adhesion, or, in other words, the co-efficient of friction between the driving wheels and the rails, varies considerably according to the kind and nature of the surfaces in contact. In dry weather, the adhesion is much greater than in wet weather when the rails and wheel tires are greasy; therefore, we have to adopt, in our calculations, a low co-efficient and provide considerable weight, in order to be able to work the locomotive safely at all times.

Again, the effort, E, on the periphery of the driving wheel should represent the *initial* force necessary to overcome the inertia of the locomotive and car; this initial force is found, in practice, to be about *four* times that of the tractive force when the vehicle is in motion; consequently, if E and Q are of sufficient magnitude to ensure the desired initial effect under the most unfavourable conditions, then the rest will follow as a matter of course.

The term "specific energy" denoted by *e* is not a happy one, and the expression $e = \frac{E}{Q}$ is misleading. Tramway engineers speak of "the tractive force" in pounds per ton (or kilograms), which is nearly a constant quantity for a given road, and within the moderate speeds allowed for street traffic; this tractive force has been found to vary between 25 lbs. and 30 lbs. per ton on level, dirty tram rails, with the car in motion; but 100 to 120 lbs. per ton is required to *start* the vehicle from rest.

Experience seems to recommend about 6 tons as the safe weight for a steam locomotive hauling a two-horse tramcar on an average tram line in towns. Larger cars and heavier locomotives are used on some country lines.

The accompanying table gives the relative weights, the proportion of dead weight to passenger weight, the relative mechanical energy applied to the driving wheels to produce a given useful effect, and the relative cost of fuel for the following cases:—

1. A separate steam locomotive hauling one car.
2. An electric automotive car carrying stored energy in secondary batteries.
3. An electric car deriving its energy through metallic conductors.

	Separate Locomotive.	Automotive car with stored-up energy.	Electric car with conductors.
Weight of empty car ... in tons	2·0	2·0	2·0
„ 40 passengers „	2·5	2·5	2·5
„ locomotive alone „	6·0	...	...
„ accumulators „	...	1·25	...
„ electric motor and gearing „	...	0·75	0·6
Total weight to be propelled ... ... „	10·5	6·5	5·1
Starting force in lbs.	1,260	780	612
Tractive force of moving vehicle—lbs.	315	190	153
Proportion of dead weight to passenger weight	3·2 : 1	1·6 : 1	1·04 : 1
Relative mechanical energy applied to the driving wheels to produce a given useful effect	2·05	1·24	1
Relative consumption of fuel if there were no losses in the electrical conversion and transmission	6·15	1·24	1
Relative consumption of fuel, assuming a loss of 50 per cent. in electrical conversion and transmission ...	3·07	1·24	1

If the tramway locomotive consumes on an average 7 lbs. of fuel per mile whilst hauling a car with 40 passengers at the rate of about seven miles an hour, we should have an expenditure of 49 lbs. of fuel per hour. On the basis of the data which served for calculating this table, the tractive force (in motion) is 315 lbs., which at a velocity of 6·16 feet per minute gives 5·87 H.P. effective, on the driving axles. The consumption of fuel is therefore 8·35 lbs. per horse-power per hour.

An economical stationary, compound condensing steam engine of reasonable dimensions consumes not more than one-third this amount of fuel (of the same quality), consequently the relative cost for this item shows a vast difference when neglecting the losses attending the conversion of mechanical into electrical energy and *vice versâ*.

The losses arising in the transmission of electrical energy in the case of conductors depends upon the size and length of such conductors, whereas with secondary batteries it is a constant known quantity. We have assumed, for the sake of argument, that this loss is 50 per cent. in both electric systems; we have thus a margin of 59 per cent. in favour of the automotive accumulator car, and 67 per cent. in that of the electric car with conductors.

It is an easy matter to ascertain with the utmost accuracy the total efficiency of an electric apparatus, and thus modify the above figures accordingly, and our present object has been to render the comparison in a practical form. The efficiencies of dynamos, motors and other apparatus would have to be very low indeed in order to bring the cost of fuel level with that of tramway locomotives.

The work of the jury at Antwerp, although not conclusive, has brought the subject of mechanical traction on tramways prominently before the world, and the results arrived at cannot fail to command attention.

Perhaps, some day, more extensive and more searching tests may be instituted in this country, and these should include other systems, such as compressed air, fireless engines, gas and petroleum motors and cable traction, all of which deserve every encouragement.

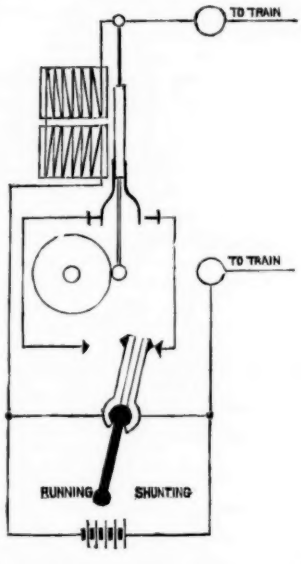
INTER-COMMUNICATIONS AND BREAK-AWAY SIGNALS IN TRAINS.

By THOMAS PAUL,
Foreman, Indian Government Telegraph Works, Alipore, Calcutta.

THE accompanying diagram shows a simple arrangement to attain the ends mentioned above.

The instruments used, namely, bell and switch on the engine and pushes in the different carriages, are also so simple that a description of them is not considered necessary.

When the switch is placed to "running" and the connections made as shown in the diagram, the armature of the coil is strongly attracted to the electro-magnet, and the train is ready for its journey. It is now evident that the guard or any one of the passengers is at liberty to call the driver's attention by pressing the push, provided for that purpose, which breaks the main circuit, consequently releasing the armature and causing the bell to act as one on the make and break principle. If a portion of the train becomes disconnected it will answer the same purpose, as the main circuit is again broken.



If throughout the journey shunting has to be performed, the bell will at once commence to ring as soon as disconnection of the carriages is made, and the driver is thereby reminded to turn his switch to "shunting," on which the bell will at once cease to work. When the shunting is finished and the train circuit again completed, the bell will at once operate on the short-circuiting principle, thereby reminding the driver to put his switch back to running.

By this arrangement it will be noticed that no extra springs or catches are required to prevent the hammer from vibrating when the train is in motion.

ON SURFACE TRANSMISSION OF ELECTRICAL DISCHARGES.*

By H. S. CARHART.

THE Report of the Commissioner of Patents for 1859, volume "Agriculture," contains an important but little known contribution by Prof. Joseph Henry on "Atmospheric Electricity." Under the head of "Electricity in Motion" occurs this passage:—If the discharge be not very large in proportion to the size of the conductor, it will principally be transmitted at the surface. If the charge be very large, and the conductor small, it will probably pervade the whole capacity, and, as we have seen, will convert into an impalpable powder or vapour the solid particles." Of the latter statement abundant demonstration has recently come under the writer's notice. To settle the former point the author of the paper alluded to instituted a series of experiments, only one of which is described. It is fair to infer that this one was deemed the most conclusive. The arrangement in his own words was as follows:—"C, D, is a copper wire . . . . . of the size usually employed for ringing door bells, passing through the axis of an iron tube or a piece of gas pipe, about 3 feet long. The middle of this wire was surrounded with silk, and coiled into a magnetising spiral, into which a large sewing needle was inserted. The wire was supported in the middle of the tube by passing it through a cork at each end, covered with tinfoil, so as to form a good metallic connection between the copper and the iron. F and Y are two other magnetising spirals of iron wire, on opposite sides of the tube, the ends soldered to the iron. When these two spirals were also furnished with needles and a discharge from a Leyden jar sent through the apparatus, as if to pass along the wire, the needle inside of the iron tube was found to exhibit no signs of magnetism, while those on the outside presented strong polarity. This result conclusively shows that, notwithstanding the interior copper wire of this compound conductor was composed of a material which offered less resistance to the passage of the charge than the iron of which the outer portion was formed, yet when it arrived at the tin foil covering of the cork it diverged to the surface of the tube, and still further diverged into the iron wire forming the outer spirals."

Several years since I repeated this experiment apparently with the result described above. Doubt was cast on the demonstration, however, by the discovery in one trial that the inner needle was slightly magnetised.

It is evident that the experiment is not conclusive, for the arrangement described constitutes a divided circuit in which one branch, consisting of the gas pipe, presents much less resistance than the interior copper wire. The greater part of the discharge should accordingly pass along the gas pipe, and the magnetisation of the interior needle would be so slight as to escape detection unless a delicate method of examination were employed.

The matter seemed to be of sufficient importance to justify an experimental inquiry. The investigation has been more extended than was anticipated, because it has met with greater difficulties than were at first apparent; but the results obtained are of considerable interest, and the conclusion of the whole matter settles the main question.

The following arrangement of apparatus was adopted. Two glass tubes about 15 mm. in diameter were covered with tin foil for a length of about 1 metre each. About the tin foil at each end was secured tightly a copper clamp. Two similar magnetising spirals were made by winding 20 turns of gutta percha covered wire round small glass tubes. One of the spirals served to connect the two tin foil coatings in series by having its terminals soldered to the copper clamps. The other formed the middle of a circuit extending through the inside of the tubes. The two conductors were then joined at the remote ends of the glass tubes so as to form a divided circuit—one of the tin foil and connecting helix, the other of the wire passing through the inside of the tubes and containing the other helix. *The two branches were adjusted to very accurate equality of resistance.* Through this compound circuit a Leyden jar was discharged; and the method finally employed to measure the relative portions of the charge passing through the two branches was to determine the magnetic moment imparted to two similar rods of steel, 1·8 mm. in diameter and 6 cm. long, tempered glass-hard, one inserted in each spiral. The Leyden jar of about 700 square centimetres surface was charged by a Holtz machine with 15 sparks from 2 to 3 centimetres in length. The magnet in the inner branch of the divided circuit will be called A; the one in the outer, B.

* From the *American Journal of Science*, Vol. XXXI., April, 1886.

What Hughes calls "the evident magnetism" of A was in every case greater than that of B after a single discharge of the jar. Upon sending repeated discharges through the circuit, the ratio of the two magnetic moments gradually diminished and the moments themselves approached a maximum, as is shown in fig. 1, where the ordinates denote magnetic moments and the abscissæ discharges of the Leyden jar. The moments in arbitrary units are simply fractional parts of the deflection of the magnetometer, consisting of three pieces of magnetised watch spring attached to the back of a plane mirror. This small magnet was about one centimetre long; and, with the attached mirror, was suspended by a cocoon fibre 10 cm. long, after the manner described by Gray.* The deflections were

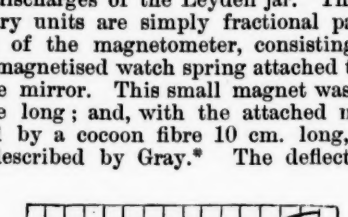


FIG. 1.

read by a telescope and scale at a distance of 1·8 m., though this distance varied somewhat in the different sets of experiments, inasmuch as the only quantitative comparisons made were between each pair of magnets used in the magnetising spirals. The maximum moments were usually attained at 10 discharges, the magnetisation of the two rods being then pretty nearly equal.

After this nearly stationary condition had been reached, some unexplained facts led to an exchange of the two magnets in the spirals, keeping them turned so that a subsequent discharge would still magnetise them in the same sense as before. A single discharge of the Leyden jar then sufficed to increase the magnetic moment of B from 50 to 60 per cent., and to diminish that of A about half as much, as shown in fig. 1. This was repeated many times with the same invariable result. Continuing the discharges the ordinates of

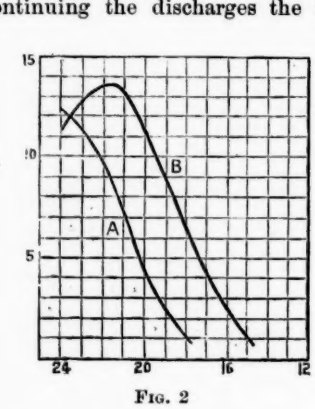


FIG. 2

both curves increased as shown. After the magnetisation of both rods had approached an apparent maximum, therefore, the mere exchange of the magnets in the spirals was followed by this striking result.

Not finding any information guiding me to an explanation of this curious behaviour of the magnets, I sought it by an examination of the physical condition of the magnets themselves after they had reached the maximum of magnetic moment with 10 discharges. The outside was gradually eaten away with nitric acid, the magnets weighed after each immersion in the acid, and their magnetic moments determined. The results of this process with one pair of magnets are plotted in fig. 2, in which the ordinates are magnetic moments and the abscissæ are weights in units of 50 milligrams. The curves therefore represent magnetic moments decreasing with weights. It will be observed that the moment of A decreases from the first continuously, while that of B first rises to a maximum and then falls according to the law exhibited by A. These curves afford a complete explanation of the anomalous deportment of the magnets upon exchanging them in the coils. B has a thin external shell magnetised in a sense opposite to that of the underlying portions. When B takes A's place, this external magnetism is reversed by the first subsequent discharge and made similar to the underlying portions; while A, being placed under B's former conditions, suffers a reversal on the exterior, thus losing in resultant magnetic moment, or "evident magnetism." When the magnets are examined after a single discharge of the Leyden jar they give rise to exactly similar curves, except that the reversed portion of curve B is somewhat longer.

An examination of the conditions under which an oscillatory discharge takes place, and particularly of the formula for the period of an oscillation, will throw light on the reversed curve of B. The first mathematical discussion of electrical oscillations was by Sir William Thomson in 1853,* and was founded on the "Equation of Energy." Kirchhoff† subsequently arrived at similar equations by introducing into the expression for the electromotive force a coefficient of self-induction. Later writers, Chrystal,‡ Mascart and Joubert,§ have followed the method of Kirchhoff. These investigations show that the discharge will be oscillatory when $R < \sqrt{\frac{4L}{C}}$, in which R is the resistance of the discharger, L the coefficient of self-induction, and C the capacity of the principal conductor. The period of an oscillation is $\frac{\pi}{n}$ where $n = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$ When R is very small, the period of an oscillation is proportional to $\sqrt{LC}$. In all my experiments the greatest value of R, not including the air resistance of the spark, was 0·58 ohm. We may, therefore, for our purposes consider the period of an oscillation jointly proportional to the square root of the capacity of the principal conductor and of the coefficient of self-induction. This inference, so far as it relates to the capacity of the principal conductor, was confirmed by some experiments of Helmholtz in 1869.‖

The bearing of the duration of an oscillation on the reversal of the superficial magnetism is that the mean intensity of the current during the first period is inversely proportional to the length of the period, since the whole quantity of electricity on the principal conductor is discharged during this short interval. Then the magnetic moments, being nearly proportional to the current strength, so long as the saturation point is not approached, will therefore vary inversely as the periods of an oscillation, or inversely as the square root of the coefficients of self-induction, in the two branches of the discharger, even though the quantity discharged through the two branches is the same. The magnetic impulse of both the direct and reverse oscillatory discharge is greater the smaller the coefficient of self-induction in the discharger.

* "Absolute Measurements in Electricity and Magnetism," p. 6.

* Mathematical and Physical Papers, vol. i., p. 540.
† Gesammelte Abhandlungen, "Zur Theorie der Entladung einer Leydener Flasche," p. 168.
‡ Encyclopædia Britannica, vol. viii., p. 81.
§ Electricity and Magnetism, vol. i., p. 512, English edition.
‖ Wissenschaftliche Abhandlungen, "Ueber Elektrische Oscillationen," p. 531.

In the experiments thus far described no care was taken to make the coefficient of self-induction in the two branches equal to each other. The inner branch was of copper wire longer than the glass tubes, and coiled into a long helix with the consecutive turns far enough apart to prevent a spark from leaping across. This disposition of the wire increased largely its self-induction. The time of an oscillation through it was therefore greater than in the outer branch, and the magnetic effect of the weaker current less, while the whole quantity discharged through the two branches was the same. Not only then was the mean magnetic moment of B greater than that of A, but the effect of the return discharge was sufficient to produce a reversal of magnetism in B near the surface.

These conclusions are fully confirmed by experiments made with a new arrangement of apparatus, so devised that the coefficients of self-induction in the two branches should be as nearly equal as possible; while at the same time their capacities were made more nearly equal than before, in order to eliminate any possible effect on the period of an oscillation arising from dissimilarity in this respect.

Two large tubes, 22 mm. in diameter, were covered with tinfoil for a combined length of 265 cm. Two other tubes 15 mm. in diameter, were also covered for a combined length of 296 cm., and the smaller tubes were placed inside the larger ones. One of the magnetising spirals was made to connect tho outer tubes in series, and the other, the inner ones, the other ends of the tinfoil conductors being joined by means of copper clamps and short pieces of wire, so as to make a divided circuit of two branches as before. The cross-section of the tinfoil conductor on the inner tube was made as nearly as possible equal to that of the outer, so that equality of resistances was secured without introducing materially different lengths of wire into the two branches. The resistances in every case were adjusted to equality by means of a sensitive mirror galvanometer and a Kohlrausch bridge.

With this apparatus the magnetic moments of two magnets of equal weight, cut from the same steel rod and tempered together, are almost exactly equal; and the curious phenomenon exhibited in fig. 1, when the magnets exchanged places in the two coils, very nearly disappears. What is perhaps more to the purpose, the lateral distribution of magnetism in the two magnets is practically identical. Two steel rods as before were placed in the magnetising spirals: and after 10 discharges of the Leyden jar, an examination was made by gradually removing the outer shell with nitric acid and determining the magnetic moment after each removal of about 50 mgs. The two resulting curves, shown in fig. 3, are nearly identical. Both show the

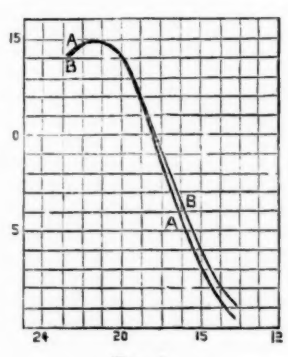


FIG. 3.

same superficial reversal of magnetic polarity. In fact, if curve B is rotated clock-wise through a small angle round its highest point it will coincide with that of A. The depth to which this reversed magnetism extends depends, therefore, almost entirely on the coefficient of self-induction of the discharger, the principal conductor of definite capacity being charged to a given potential. When the only dissimilarity between the two branches of a divided conductor is that one is placed inside the other, there is no dissimilarity in the quantity or distribution of the magnetism produced in similar coils in the two branches by a discharge through the compound circuit. There is no evidence of a tendency toward surface transmission. The law of resistance pertaining to dynamic currents applies also to electric discharges. The resistance is a function of the area of the cross-section and not of the periphery of the cross-section.

A practical bearing of the investigation is that there is no sufficient scientific basis for making lightning conductors of large surface; and that large sectional area is essential to ample conductivity.

THE STRANGE HISTORY OF A DYNAMO

As told by itself to

A. DYNAMICABLE.

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(*Continued from page* 444.)

YOU wish me to give an illustration of this self-exciting reaction, or mutual accumulation principle. With pleasure I do so. If you examine this sketch you see therein the revolving armature or ring, A, and the electro-magnets, M, connected together from the collecting brush, *a*, in a common or simple circuit through the external portion of that circuit, L, L, which may be electric lamps, for instance, to the other

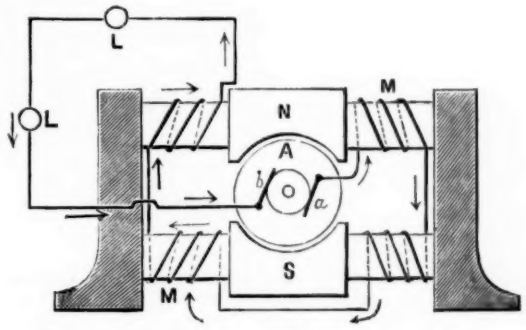


DIAGRAM EXPLANATORY OF THE RE-ACTION PRINCIPLE.

brush, *b*. You remember I told you that even the softest iron contains traces of residual magnetism, therefore please consider the iron pole pieces, N, S, of the electro-magnets as being feebly magnetic. You also know that an electric current traversing a wire coiled upon an iron bar or rod makes this latter into a powerful magnet; also, from preceding illustrations, that a coiled armature similar to that, say, of Pacinotti, will have currents induced in itself when revolved between magnetic poles. These facts are all sufficient to explain the great discovery made by Varley. Now let us set the armature in motion; a very feeble current is set up in the ring which circulates also through the electro-magnets, these being in a common circuit with the ring. This current renders the electro-magnets somewhat stronger; with increased magnetism, therefore, the current in the ring becomes more powerful; this, in its turn, develops still greater magnetism, and so there is set up between the ring and its field-magnets a sort of reaction or mutual accumulation, which goes on increasing until the magnets become what is termed *saturated; i.e.*, any excess of current beyond that which brings the electro-magnets to this state of excitement is of no further avail; no

more magnetism can be developed. Now I think you understand the self-exciting principle and its advantages. We require no permanent magnets for the "magnetic field," and no galvanic battery to excite the electro-magnets; we simply make use of the slight trace of active magnetism which exists in the iron as a fulcrum for converting the mechanical force necessary to rotate the ring into electrical energy.

It is by no means an easy matter to remove impressions which are more or less stamped with the authority of tradition, and it is no less difficult to eradicate a belief in which we have been fostered since early childhood. The proofs which are brought forward to dis-illusion us must be irrefutable; and, in this instance, I think that you and every one of your countrymen, whose love of fair play and no favour is inherent to the English nature, will become convinced by the facts which I now bring before you that Mr. S. A. Varley antedated his illustrious colleagues in the discovery of the self-exciting principle of the dynamo. Some years ago, I think in the year 1877, a controversy which extended over some length was begun on this very subject in the pages of one of the most influential and respected of English technical journals, *Engineering*. Mr. Varley himself, the late Sir William Siemens, the late Robert Sabine, and others well known in the electrical world of that time, took part in this discussion; the result of which was thus concisely, and in good faith, summed up by Mr. Sabine :—"Prof. Wheatstone was the first to complete and try the reaction machine.

"Mr. S. A. Varley was the first to put the machine officially on record in a provisional specification dated the 24th of December, 1866, which was therefore not published till July, 1867.

"Dr. Werner Siemens was the first to call public attention to the machine in a paper read before the Berlin Academy on the 17th of January, 1867."

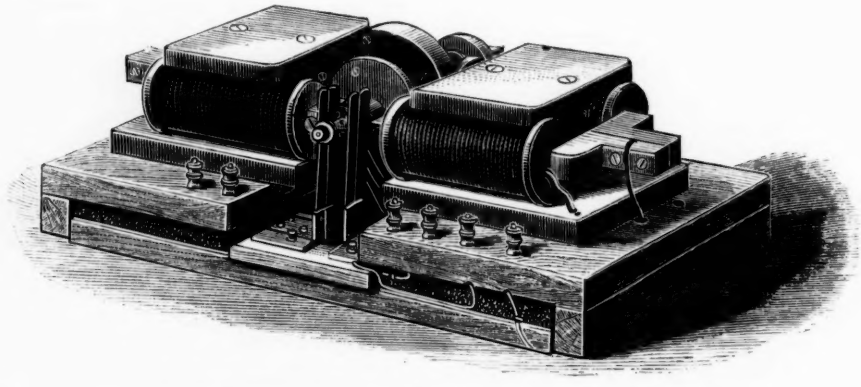
The reasons which influenced the writer of these paragraphs to such conclusions will be made manifest as I proceed.

I, however, cannot content myself with accepting a statement which, after all, is not a decided opinion upon the merits of this vexed question, but a sort of conciliatory concession to the three interested parties. At the time of which I speak dynamo construction was in its infancy, and probably it was then thought that the matter was less important than was actually the case. Moreover, the present race of electrical engineers, more particularly those who are now most intimately associated with my welfare, may be unaware of the existence of the correspondence to which I allude, and which, of course, affected me deeply; I must, therefore, through you, ask my readers' pardon if I refer to this almost forgotten circumstance at some length.

It seems that in the excellent journal to which I have referred there appeared in the month of October, 1877, an article on "The Electric Light." But little was known of the subject at that time, and therefore any able writer was sure of attentive readers, and, as the knowledge possessed on this special matter was then so limited, it follows that any slip or mis-statement made from inadvertence or ignorance would be taken up by the few who had complete command of the circumstances of the case. The first comment thereon was made by the late Sir C. William Siemens who, a few days after the appearance of the article in question, replied thus :—"You say, the most important discovery connected with this subject was made by Dr. C. W. Siemens and the late Sir Chas. Wheatstone simultaneously, but independently of each other, and the discovery was brought before the Royal Society on the same evening." Sir William then continued :—"It is true that upon that occasion I presented to the Royal Society a paper describing the action of a machine which I had constructed in this country, but the merit of the discovery of the principle upon which it acted is really due to my brother, Dr. Werner Siemens, who presented a memorial to the Berlin Academy of Sciences on the same subject fully a month previous to the two communications referred to in your article. This communication was not published at the time the Royal Society papers were presented, but suffices to give Dr. Werner Siemens a prior claim." I have already mentioned that these communications were brought before the Royal Society in February, 1867. In the same number of *Engineering* in which the letter of Dr. Siemens appeared, another from Mr. S. A. Varley was also published. This gentleman expressed himself in these words :—"Allow me to point out that in the previous year I had constructed and provisionally protected a dynamo-electric machine in which the soft iron magnets were employed, the feeble magnetism of which formed the fulcrum for mechanical force to act upon and develop electricity and magnetism on what you describe as the 'action and reaction principle of magnetisation,' and that therefore I have a prior claim for the invention of the principle on which *all* the subsequent powerful dynamo-electric machines which have been since introduced are based."

Mr. Varley's specification was dated December 24th, 1866, and this date I wish you to keep in your memory.

To Mr. Varley Dr. C. W. Siemens replied that it appeared strange that when the first publication of the principle in question took place before the Royal Society—Dr. Siemens here refers to the reading of his own paper before a public body of scientific men on the 14th February, 1867—Mr. Varley did not come forward to join in the discussion, which created much interest. It was not apparent to me, and I expect you will agree with me in this, what Mr. Varley's absence from the Royal Society's meeting had to do with the point at issue. Dr. Siemens moreover remarked that



VARLEY'S ORIGINAL MACHINE, CONSTRUCTED IN THE YEAR 1866.

his brother Werner tried his first experimental machine before Christmas, 1866, and whilst expressing the highest regard for Mr. Varley's ingenuity he claimed that this gentleman had therefore been anticipated. Mr. Varley, however, had still something "up his sleeve." His next communication was to the effect that his dynamo was completed and tried at the end of *September*, 1866. This, one would have thought, was a poser, but Dr. Siemens was an adept in the art of fencing. There is, said he, in still another lengthy letter, a circumstance connected with the provisional specification itself which would lead one to suppose that at the time of its being deposited in the Patent Office Mr. Varley could not have submitted it to actual trial.

The specification says:—"Before using the apparatus we generally send an electric current through the electro-magnets; the object of this is to secure a small amount of *permanent* magnetism in the direction we wish in the soft iron cores of the electro-magnets." This extract is that upon which Dr. Siemens implied that Varley had not submitted the machine to an actual trial for, said he, no such excitement of the electro-magnets is at all necessary for starting the apparatus in action, terrestrial magnetism, or a magnetic tension in the iron, being sufficient to engender the requisite action. Mr. Varley's reply to this showed conclusively why he *generally* sent a current through the coils first, and also that he was aware theoretically that such a procedure was unnecessary in some cases, although practically essential in others. Just when the controversy had reached this interesting situation Mr. Robert Sabine came upon the scene with positive proofs that machines on the same principle were constructed for, tried, and invoiced to, Sir Chas. Wheatstone, on the 12th September, 1866. This, however, only shows that Mr. Varley and Prof. Wheatstone were independently working at the same idea, and that the latter was lucky enough to get his apparatus in operation a few days earlier than did Varley.

The date when an undefined idea of making any machine first occurs to an inventor is of very little comparative importance, and in which of the three claimants to the honour of having discovered the reaction principle the first happy inspiration was born, we can scarcely expect to know. I myself think that the arguments and proofs brought forward by Dr. Siemens on behalf of himself and brother go to show that Wheatstone was ahead of him. Wheatstone and Varley may have nurtured and developed the germ for months, aye years, before putting it into practical form. Varley indeed goes so far as to declare that he did not even commence his machine until he obtained, by previous experiments, the data upon which it was constructed and from which he anticipated the actual results which were obtained therewith. Wheatstone certainly never patented his discovery and therefore he, unlike Varley, could have had no reason for withholding its publication. Wheatstone was President of the Mathematical Section of the British Association in 1866, and it is customary for those in office to report to the sections over which they preside the progress made between consecutive meetings. This was in the last week of August, and one can scarcely imagine that Wheatstone, a man jealous of his rights as a scientific discoverer, should have let slip such an opportunity as this for announcing a fact which was destined to become of such vast importance. *Prima facie* evidence is decidedly in Varley's favour, even so far as the conception of the idea is concerned; the *documentary* evidence of the invention is conclusive. Although Wheatstone and Siemens *publicly* read papers upon the subject at the beginning of 1867, Varley had deposited a document fully describing the reaction principle in the English Patent Office at the end of 1866. To him, therefore, in the absence of further evidence, must be conceded the honour hitherto associated with the names of the eminent electricians now, alas! taken from amongst us. The original machine which Varley constructed in 1866 is here to be seen in the very building under whose roof we have met together, and you can at your leisure examine it and ponder over the vicissitudes which beset the inventive genius who cares nothing for publicity, but whose heart and soul lies in the advancement of the science for which he labours.

To be modest and retiring is now-a-days a grave error; the odds are greatly in favour of someone with a keener eye to the main chance snatching the fruits of one's lifelong labours, and gaining notoriety and fame from a few indiscreet and ill-timed utterances of the enthusiastic worker with reference to his own researches.

But I must not moralise for I have yet much to tell you, and more anon directly concerning another invention of Varley's which is an all-important factor in the successful working of dynamos.

(*To be continued.*)

THE PADDINGTON CENTRAL STATION LIGHTING.

On Monday evening last the Directors of the Telegraph Construction and Maintenance Company gave a Press exhibition of the electric lighting of the Great Western Railway Company's premises at Paddington.

The installation has been undertaken to test the practicability of central station lighting, and the result will be watched with much interest.

The district lighted consists of Paddington Passenger Station, with all its offices; the Great Western Hotel; the Goods Station, with its offices; the Royal Oak Station, with its offices; the Locomotive Station, with its offices; Westbourne Park Sation, with its offices; all yards, roadways and approaches to the various stations; and the line from Westbourne Park to Paddington, the district being 1¼ miles long and covering 67 acres of ground.

The contractors state that the light is given by 4,115 incandescent lamps, each it is said of 25 candle-power; by 98 arc lamps, each of 3,500 candle-power; and by 2 arc lamps, each of 12,000 candle power; the total light is thus equal to that of about 30,000 ordinary gas jets.

The contract with the Great Western Railway Company provides that every lamp should have a separate switch, so that it can be turned on and off independently. The incandescent lamps are entirely under the control of the users, *and out of the control of the contractors*, exactly as in the case of gas. *The current is always on* day and night, except for three hours in the daytime on Sunday, when it is interrupted for testing purposes.

The contract supply was commenced on April 21st, and has continued without hitch or difficulty up to the present time.

A double system of mains is laid throughout (not twice the necessary quantity of wire, but instead of one main of a certain section two of half that section), and in every room, building, yard, &c., half the lights are on one circuit half on another, and these two circuits are worked by different machines, so that in case of either system breaking down no single room would be left in darkness. In some of the bed rooms of the hotel where only one lamp is paid for two are erected on different circuits, and a switch is provided such that either can be lighted at the desire of the inmate, but not both at once.

The engine house is situated near Westbourne bridge, at the top of Westbourne Terrace, and occupies a fairly central position in the district.

The system is that of Mr. J. E. H. Gordon, the manager of the Telegraph Construction and Maintenance Company's Electric Light Department, whose machine was fully described and illustrated by us in the Review for October 28th, 1882.

There are three Gordon dynamos, of which two work and one is kept in reserve. Thus, two dynamos work the whole system, which absorbs at the heaviest hours some 800 electrical horse-power.

These dynamos weigh 45 tons each. The sole plates are 18 feet long, and the revolving magnet wheels are 9 feet 8 inches in diameter and weigh 22 tons each. They run at an uniform speed of 146 revolutions per minute.

The dynamos are wound to give a pressure of 150 volts. It is found that with these large machines the *shock from 150 volts is very slight*, and can be taken with perfect impunity. It is much less, we are told, than that of a small direct current machine working at the same pressure.

When all lamps at present installed are on, the machines give about 2,000 ampères each.

The dynamos are respectively driven by three compound tandem engines by Rennie, of the vertical inverted cylinder type, each engine having two low pressure cylinders and two high pressure on the top of them. These engines are capable of indicating 600 horse-power each. The dynamos are driven direct, no belts being used. The magnets of the large dynamos are excited by three Crompton direct current machines, each driven direct by a Willans engine. The speed of these small machines varies from 200 to 350 revolutions, according to the lamps in use. Their speed is controlled by a wheel placed on the big engine, whose dynamo they are exciting, and worked by the engineer, so as to keep the

electric pressure constant, as shown by voltmeters placed on the big engine. A switch board is provided, by which any exciter can be connected to any dynamo.

At night two big dynamos are run, one on each circuit. In the day time both circuits are connected into one, and if the day is dull one big dynamo is run. If it is so light that not more than 150 lamps are wanted, two exciters only are run. The average "day circuit" load during the dull weather of last week was about 400 to 600 lamps.

The engines are supplied with steam by two lines of steam pipes, so that in case of a pipe or joint bursting one line can be shut off without interrupting the supply. The steam is generated in nine large boilers of the locomotive type, made at the Great Western Railway Works at Swindon. Not more than five or six are ever in use at once.

The water is supplied from three independent sources, *i.e.*, the Grand Junction Company's mains, the Canal Company's supply and the hydraulic accumulators used to work the cranes and turntables in the station. Water can be introduced into the boilers by three methods, *i.e.*, (1) cold, by the hydraulic pressure; (2) cold, by injectors; (3) hot, by a steam pump and a special hydraulic ram; the water being heated by some of the waste steam. The first two methods are only used in case the hot pump breaks down.

Welsh coal of a special quality is used, and the furnaces are specially constructed, so that no smoke whatever is produced.

The invisible products of combustion and the waste steam are discharged through two chimneys, 90 feet high, whose tops are far above the chimney pots of the neighbouring houses.

In order that no noise, which might annoy the neighbouring houses, should be produced by the dynamos, they have been cased in by a double wood and felt casing, with double-glass windows. This casing is of a peculiar shape, so that the dynamos act as their own fans, and suck air from the room. This air is conducted along wooden shoots through wire gauze screens, and discharged out on the railway line away from the houses. These screens break up the sound-waves and destroy the sound.

The mechanical ventilation thus produced enables a double roof and double doors to be used to the engine-room, and the result is that no noise can be heard outside the building.

The distributing apparatus is in a gallery in the engine room. It consists, 1st., of the main switch board; 2nd., of the Gordon divided main apparatus.

The switch board is of slate, and is 18 feet long and 8 feet high. By means of it any dynamo can be connected to either or both the circuits, or an exciter can be connected direct to the circuits. One dynamo can be exchanged for another without interrupting the light and without making a perceptible flicker. Any particular district can be disconnected for testing.

The divided main apparatus is, perhaps, the most important part of the system, for by its use the quantity of copper required in the feeding mains is reduced to *one-tenth* of that used in the ordinary method.

The principle of it is as follows:—In any feeding main the electric pressure at the far end is less than that of the dynamos. The fall of pressure is greatest when all the lamps that the main has to carry are on. If the main is thick and expensive this maximum fall is small, if thin and cheap it is great. When only a few lamps are on the fall is very small. Thus, as lamps are turned on and off there is in an ordinary main *a variation practically equal to the fall.*

As we cannot allow a variation of more than 2 per cent., very thick mains have to be used on the ordinary system, so that the fall may not be more than 2 per cent.

The object of the divided main system is to allow a fall of 20 per cent. to be used. For this purpose the feeding main consists not of one wire but of a bundle of wires connected into one at each distant feeding centre. There are five of these distant centres in the district, and they are supplied by twelve feeding mains. Contact apparatus worked by wheels in the gallery allows the component wires of each feeding main to be disconnected one by one. Fine wires come back from each feeding centre to the gallery, and actuate voltmeters and pilot lamps so that the exact brightness of the light in every part of the district can be seen in the gallery. Suppose, now, a certain number of lamps are switched off in, say, the Hotel, its pilot in the gallery brightens a little and calls the attention of the attendant to the voltmeter. He then moves the contact wheel, and cutting out a segment of the main reduces its total section, and so increases its resistance and brings back the pressure to its normal value.

To sum up, the thickness of an ordinary main is constant, and unless it is very large the variations of current caused by turning lamps on and off cause variations of electric pressure. In the divided main, *the section is variable and is kept always proportional to the current the main has to carry*, and so the electric pressure is kept constant with a main of one-tenth of the section required for the ordinary system.

The pressures in use at Paddington are:—"Dynamo centre," i.e., district near the engine house, 150 volts (for this part the divided main is not used). Passenger and goods stations and hotel, 120 volts; locomotive station and Westbourne Park, 100 volts. Different lamps are, of course, used in the different districts.

The feeding centres consist of cupboards, each in a central part of its district, provided with switch-boards, from which the current is distributed to the different corridors, offices, arc lamps, &c., and by means of which each branch main can be disconnected when required, and any fault thus localised immediately. Each feeding centre is in telephonic communication with the gallery of the dynamo room.

All mains are laid underground.

The incandescent lamps are all in parallel. The arcs are two in series, each pair being in parallel with the incandescent lamps and being fed from the same mains. In series with each pair of arc lamps is a resistance of peculiar shape, calculated from a formula of Prof. Clerk-Maxwell's to have the maximum possible self-induction. These resistances are so adjusted that when the lamps are right they have very little effect, but directly the carbons run together the resistance increases greatly and chokes any rush of current.

Tin safety fuses are used throughout to guard against any possible fire-risk. The current passes through nine of them in its way from the dynamo to any lamp.

There is a test room in the gallery provided with reflecting galvanometers, &c., by which the condition of the mains is kept constantly under examination, and any fault can be localised within five or six yards.

Some idea of the magnitude of the work may be formed from the following miscellaneous figures:—

500 miles of wire have been used.

The wires in the offices and corridors are enclosed in wood casing. Of this 12 miles have been used.

The casing is fixed to the walls by 94,000 screws.

The underground mains are contained in thin iron troughs like rain water gutters with lids. Of these 140 tons have been buried.

About 25,000 joints have been made. 20,000 labels have been used for ends of wire. Two tons of terminals and "connectors" have been used. 260 yards of massive masonry (in a number of short lengths) have been built under the lines to prevent the weight of the trains crushing the mains where they cross under the lines.

It is considered by the promotors of this scheme that big machines are as important as big gas works, and that a large installation worked by a number of small machines is no more likely to be a practical success than a large gas works would be if instead of the usual plant were substituted several hundreds of the little gas works sold for country houses.

We understand that no data have yet been compiled respecting cost, the percentage of available electrical energy for power initially supplied and matters of this kind. There is little doubt that Mr. Gordon has tried his utmost to foresee any possible combination of circumstances likely to arise which would militate against the success of his central station system, and to provide against chance of failure. The dynamo and engine-room with the switching and current measuring apparatus is arranged in a very workman-like manner, and is a great credit to Mr. Gordon. In regard to the telephonic communication necessary to enable the electrician in charge at the central station to equalise the current, it seems that a system designed for domestic lighting would have to do without this, but the requirements of a railway terminus, such as that at Paddington where considerable variations of the current used may be made at any moment, are exceptionally severe, and therefore the necessity for the said telephonic arrangements cannot in this instance be taken as a sign of weakness inherent to the system. Although there are several points in this installation to which exception might be taken, yet in the absence of figures further criticism does not here appear necessary; we will await the lapse of time before entering more minutely into details. The installation has been so long in hand that we have had occasion more than once to refer thereto; now that it is completed we congratulate Mr. Gordon and the Telegraph Construction and Maintenance Company upon the solid and substantial manner in which their labours have ended, and we heartily wish success to the undertaking.

INCANDESCENT LAMP PATENTS.

EDISON *v.* WOODHOUSE AND RAWSON
AND
EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY *v.* WOODHOUSE AND RAWSON.

(*Before* MR. JUSTICE BUTT, *sitting for* MR. JUSTICE NORTH.)

Monday, May 10th, 1886.

(*Continued from page* 449.)

SIR FREDERICK BRAMWELL, examined by Sir Richard Webster: Then, I think, you have what I called attention to, that line 34, in which he says the carbon sticks may be also free?—Yes; he goes on to say, "The carbon sticks may be also freed from air in this manner, and be brought to a temperature till the carbon becomes pasty, and if then allowed to cool is very homogeneous and hard. Rods or plates made of mixtures of finely-divided conducting and non-conducting materials may thus be freed from air. It is also obvious that the metal might be heated by subjecting the containing bulb to a considerable temperature, but this only partially frees the wire from its air or gases."

In the description of the lamp at figure 4am I right in saying that there is nowhere, in any part of this specification, a description of the carbon conductor as the conductor for the lamp?—According

to my recollection there is not, except the reference to carbon which I have just read. I do not think there is any reference to carbon as being used as a conductor for the lamp.

And no disclosure of the carbon filament in the lamp?—No. That is, according to my recollection.

Mr. CHARLES: Look at Claim I?

Sir RICHARD WEBSTER: "The combination with a sealed vacuum chamber made of a glass vessel of a continuous incandescent conductor wound upon a bobbin of infusible material, substantially as set forth." Is there any conductor wound upon a bobbin, except the platinum described?—Yes. He is going to cover his platinum with oxide of some kind or another, but nothing in the nature of carbon.

Just say what you find described in Gimingham's specification, so far as the lamp, or part of a lamp, is concerned?—An extremely simple mode of making a holder for a carbon filament so as to connect it with the platinum wires which lead to it, by flattening out the ends of the wire, bending it round into a socket suitable to receive the ends of the filament, and inserting the filament into it.

And so far as you know is there any anticipation of that mode of combination of the carbon and the platinum?—I know of no combination in an electric lamp of anything of the kind. The one that is referred to shows the bobbin of Mr. Edison. Mr. Edison proposes to take a little block of boxwood, or other suitable wood, makes the two holes in it, inserting the carbon filament into one of the holes, inserting the wire into the other, perferably with a little sugar and water round it, then carbonises the whole, so as to burn his wooden plug into a charcoal plug.

Take this lamp (handing lamp to witness), which is admittedly a lamp made by the defendants, and tell me what you find there in common with, or resembling, the combination you have described as Edison's novelty?—I find a vessel wholly of glass containing a filament of some kind, the appearance of which is consistent with its being carbon. The leading wires appear to be platinum, and they are sealed through glass; the glass has apparently been exhausted.

You say the combination there is the same combination as that of Mr. Edison?—Yes.

Cross-examined by Mr. CHARLES: Can you tell me whether the filament of this lamp bears any trace of being made of a fibrous material?—I cannot say that it is, but there is nothing to show me that it is not.

Will you kindly tell me again what you say is the characteristic of this invention of Mr. Edison?—That it made that which was before an impossibility into a commercial success.

Can you tell me whether the lamps made under the patent 4,576, and in the mode described in the patent, have been a commercial success?—I think so.

Has Mr. Edison ever to your knowledge himself used that which is described in 4,576?—I should say so. I have been to his factory and seen the lamps there, and I say the lamps were made there under 4,576, or whatever the American number may be which corresponds to 4,576, and, added to that, a final exhaustion when I saw them making.

Will you look at Edison's patent 5,127, dated December 18th, 1879, in which he says:—"My present invention relates to an improvement in the method of manufacturing the carbon filaments and the means for securing the same to the conductors. I make use of paper of the desired thickness, as free as possible from foreign substances or adulterations, and for this purpose I prefer and use Bristol board. With suitable instruments, such as a punch and dye, I cut out a narrow strip of this paper, preferably in the form of an elliptical bow, or an arc of a circle, the two ends of the strip being by preference wider than the other portions; a number of these pieces of paper are laid flatwise in the bottom of a mould, preferably of wrought iron, and there is laid on them a light weight in the form of a flat piece of gas retort carbon, or other device that will not be disturbed by the heat. If several of these are laid one on the other in the mould, a piece of tissue paper is interposed between each one and the next; a cover is used to close the mould, and the mould is raised very gradually to a temperature of about 600 degrees Fahrenheit. This allows the volatile portions of the paper to pass away, and, at the same time, the mould retains its proper shape, and the paper is prevented from curling up or becoming distorted, as it would be likely to do if the heat was applied suddenly, or the light weight dispensed with. The mould is now placed in a furnace and heated almost to a white heat, and then removed and allowed to cool gradually. The carbon filaments will be found to be smaller than the cardboard blanks, and to be sufficiently strong and flexible for handling. The ends of the carbon are to be joined to the metallic conductors in any convenient manner. The carbon filaments prepared as aforesaid are very uniform in their resistance to the electric current, and I make them thin and of a sufficient length to offer a great resistance to the passage of the current. The clamps that connect the conductors to the ends do not require to be pressed with much force on the carbon, because the resistance to the passage of the current between the clamps and the carbon will be less than the resistance of the carbon filament, hence but little heat will be developed at the clamps. In ordinary electric lamps the large carbons do not offer much resistance to the electric current, and unless the clamps are very firmly pressed upon the carbon the current meets with considerable resistance at the clamps, and heat is developed at such clamps." In the Edison lamps, of which you have had experience, are the carbons manufactured in the way pointed out here?—No.

Now turn back to patent 4,576, in which that described as a carbon filament is alluded to.—The things I have seen in the course of manufacture have been prepared from fibrous materials—mainly strips of bamboo.

Will you refer to specification 4,576. On page 3: "I have discovered that even a cotton thread properly carbonised and placed in a sealed glass bulb exhausted to one-millionth of an atmosphere, offers from 100 to 500 ohms resistance to the passage of the current, and that it is absolutely stable at very high temperatures; that if the thread be coiled as a spiral and carbonised, or if any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber be so coiled that as much as 2,000 ohms resistance may be obtained without presenting a radiating surface greater than $\frac{1}{16}$ths of an inch; that if such fibrous material be rubbed with a plastic compound composed of lampblack and tar, its resistance may be made high or low, according to the amount of lampblack placed upon it."—Yes; I say that the filaments I saw being made out of strips of bamboo were in my judgment made from a fibrous vegetable substance which will leave a carbon residue after heating.

But I do not see any instruction here as to how the carbonisation is to be effected?—I believe anybody knows how to carbonise. But when he comes to deal with it he shows that it might be well to have a special apparatus for dealing with it, by laying one layer upon another, and, as a matter of fact, the bamboo strips are dealt with so.

I notice that in 5,127 he does give very minute details as to how it is to be done.—He gives particulars of a special apparatus, and I dare say he thought that he had a valid patent—and for anything I know he has—for a special apparatus for carrying out the particular object on a large scale.

Are you able to tell me now that the plaintiff does not deal with bamboo strips in the manner set forth in 5,127?—I cannot tell. I have never been upon the plaintiff's manufactory. My only practical knowledge of these lamps is derived from the highest source of all—the patentee himself.

Does he treat bamboo strips in the manner which I have just read to you?—Yes. He does not prepare them by a punch as he suggested there. My recollection is that when these bamboo strips were prepared by an extremely beautiful means to get them of uniform size, so that they might be regularly heated all through, they were carried out into iron moulds and weighted very much in the way described in the specification, and put into ovens and carbonised.

At all events, I am right, am I not, in saying that this method which he describes in his patent of December, 15th, 1879, does not appear in the specification of May 10th, 1880?—You are right.

That we attach considerable importance to. Here is another of the defendant's lamps [handing to witness]—a large one. You say with regard to the small one, that you could not say whether the material was fibrous matter or not. Can you say whether that is fibrous or not?—I cannot say, but as far as the eye would lead me to judge, I should say it was not.

There is a filament in it?—A flat band filament.

The filament, I suppose, is a thread?—Whatever the dictionary meaning of filament may mean—a filament or thread.

Mr. Edison speaks of three things. He speaks of strips in the original specification?—Yes.

I suppose a filament is a thread?—A filament is a thread. I suppose a strip is a wide thread, as though you might sew something with brass, for example.

Mr. ASTON: I do not know whether your lordship has had the definition of filament read. I have one here from the "Imperial Dictionary": "Filament (*filamenta*, threads, from *filum*). A thread or fibre. In anatomy and natural history, a fine thread of which flesh, nerves, skin, plants, roots, &c., and also some minerals are composed; also the spider's web is composed of filaments. The thread-like path of the stamens of plants is called the filament."

Mr. CHARLES: I was going to point out to Sir Frederick Bramwell that in claim number 3, whatever the "Imperial Dictionary" says, Mr. Edison appears to treat filament as a thread. He says: "A coiled carbon filament or a strip." I do not know, of course, what may be the construction of that. It is not for me. I do not know whether he means a filament or a strip, or whether he uses the term strip as being the equivalent for filament. That is not for me.

Mr. Justice BUTT: If a man writes properly, he ought not to use two expressions to signify the same thing, although very often people do that. I do not know what he has done here at present. That I have to determine.

Mr. CHARLES: I should have thought it meant a carbon filament or a carbon strip. With reference to the patent generally, you mention that King, in 1845, had disclosed a method of making incandescent lamps of carbon in vacuum?—Yes.

I must draw your attention a little more particularly to that patent. It is No. 10,919 of 1845, a patent for the invention of improvements in obtaining light by electricity. At the fifth line on page 2: "The nature of the invention consists in the application of continuous metallic and carbon conductors intensely heated by the passage of a current of electricity to the purposes of illumination." Then he goes into the suitable method, which he finds is platinum. The next page, line 16: "When carbon is used it becomes necessary on account of the affinity this substance has for oxygen at high temperature, to exclude it from air and moisture. To accomplish this in the most perfect manner it should be enclosed in a Torricellian vacuum." One of the great difficulties in the way of manufacturing successfully was the diffi-

culty, until quite recently, of obtaining a perfect vacuum, was it not?—Yes.

That was not found satisfactory?—I do not know how far it was tried; but I should say that directly the heat came on it would not be satisfactory.

However, there is a distinct anticipation of the use of carbon in vacuo for the purpose of incandescence?—Oh, yes; certainly.

And I notice that in dealing with the platinum the inventor does say that the platinum ought to be thin, "So thin that on holding it before a printed page the letters can be distinguished through it?"—Yes.

Mr. JUSTICE BUTT: This is the platinum?

Mr. CHARLES: Yes; I am pointing out to the witness that King recognised the necessity of a thin substance for the purpose.

WITNESS: The platinum being a much better conductor than carbon, if he did not have it extremely thin the current would pass through without giving what he wanted.

Mr. CHARLES: Will you look at Shephard's patent, No. 1,302, of 1850, page 9: "Apparatus for lighting in a vacuum. When it is desired to light by means of the incandescence of charcoal I employ an arrangement of apparatus similar to that which is referred to in figure 10." He then describes the globe of glass through which two insulated polar wires are passed, which terminate, one in a little cylinder of charcoal, weighted by a small cylinder of lead, and the other in a little cone of prepared charcoal or coke, against the top of which the cylinder of charcoal rests, this cone becoming incandescent when the current is established. That is a distinct invention for the incandescence of this substance in vacuum?—No, it is a kind of lighting which Sir Richard Webster did not open to his lordship, although I suggested it. It is a sort of mixed lighting, that is to say, instead of the carbons being continuous as in incandescent lighting, or being absolutely discontinuous as in arc lighting, one piece of carbon presses on the other, but the light takes place at the point, of junction.

Now look to Roberts's specification, 14,198, of 1852. That patent relates to an improvement in the production of electric currents, in obtaining light, motion, and chemical products and effects by the agency of electricity. At page 11, line 20, he says, "Another part of my invention consists of a mode of obtaining electric light by passing a current of electricity through a thin piece of graphite, coke, or charcoal, or other infusible body, being a conductor of electricity, while it is enclosed in a vacuum or space not containing any oxygen or other matter which can cause the combustion or destruction of it when brought into an incandescent state by the action of the current of electricity." At page 12, line 5: "Now the mode of operation with this apparatus is as follows:—"A piece of very thin graphite about half an inch long, half an inch wide, and as thin as conveniently can be made, is fastened at each end into the clips and firmly secured . . . . a galvanic battery is put into connection with it by the binding screws, the electricity passes through the rods and the thin piece of graphite, *j*, which becomes white hot from the passage of the electric current, and no combustion will ensue. If the vacuum be perfect, and if there be no matter within the globe to cause combustion of the graphite, or if the graphite be not otherwise destroyed, the light continues as long as the electricity flows through the graphite in sufficient strength; and with respect to this part of my invention I claim the production of light by passing electricity through a thin infusible body by a conductor of electricity in manner hereinbefore described." The author of this patent was evidently conscious of the importance of having carbon as thin as conveniently could be?—He appeared to have some notion of that kind. Why he wanted it so I do not know. If he wanted it for resistance I do not see why he wanted it half an inch wide and half an inch long. Except the thinness, he did his best to get a small resistance. It was going back from King's lamp, and was not so good as King's. In the year 1852 one has practically a repetition of King's of 1845, something filed down out of a piece of coke, graphite, or charcoal. If Edison had said: "I am the first inventor of incandescent carbon," this would be an objection.

Now I would draw your attention to Kosloff's patent of 1875, No. 441. It is a patent for "improvements in the production of electric light, and an apparatus therefor. These improvements consist essentially in the sub-division of the electric light, which is produced by means of an electric current heating to a white heat sticks of carbon placed in the circuit, and being hermetically enclosed in a globe filled with nitrogen gas, all as hereinafter set forth." Now there we have again, have we not, the production of electric light by the combustion of the carbon in vacuum?—Yes; you really have there the combustion of the carbon. That is precisely what happens. But this ingenious gentleman's notion was that he was to get his nitrogen by allowing the carbon to be wasted.

He wasted a little of his carbon, but he gets an incandescent lamp?—He intended to do. It is really a very poor attempt to get an incandescent carbon lamp.

Now will you look at the specification of St. George Lane-Fox, No. 3,988, of 1878. This is "for improvements in obtaining light by electricity, and in conveying, distributing, measuring, and regulating the electric current for the same, and in the means or apparatus employed therein. In order to produce a light I pass the electric current through a thin strip or wire of some suitable material, for which purpose I prefer to use an alloy of platinum and iridium. The electric lamp in which the lamp is produced therefore consists of two conductors, insulated from one another, having this strip, or wire, between them, and in contact with each. The material or alloy employed should be capable of standing as high a degree of temperature as possible without fusing, volatilising, or falling to pieces. It should also have a high specific resistance. The higher the temperature to which the material can be raised the more economical will be the light produced, that is, the light will be greater in proportion to the force or energy expended, inasmuch as the radiant energy proceeding from the surface of the material will be more and more luminous as the temperature increases. . . . . In order that the electric force may be conveyed at a high tension, that is, having high electromotive force, so that there may not be very great loss from the resistance of the conducting mains or conductors, I make the lamps, when I use an alloy of platinum and iridium, of lengths of fine wires, so that I may get a high resistance without having a large extent of luminous surface." Now, there Mr. Lane-Fox has apprehended the importance of the wire being fine, and a high resistance obtained without a large extent of luminous surface?—Yes.

With the exception that the material used is carbon and not metallic, is not the object achieved by the carbon filament?—The object is the same, getting a high resistance and not much surface. The means, of course, are very different. A metallic substance has much higher conducting power than carbon. I think you are rather assuming that it is metallic.

Look at page 3, line 18: "In order to produce a light I pass the electric current through a thin strip, or wire, of some suitable material."—I know of no means in his day of making wire carbon.

I see he used a hermetically sealed glass also? Look at page 4, line 5: "In figure 1 *a* represents the wire of alloy of platinum and iridium; it is suspended between the two conductors, *b*, *b*, which pass through the top, *c*, of the lamp *d* is a cover of glass, or other suitable material, cemented or hermetically sealed to the top, *c*."—I should not read that as meaning that it was sealed by the glass-blower's art. When he says "cemented or hermetically sealed" I should read it as meaning that it is to be so cemented as to be hermetically sealed.

If that is an accurate representation of the invention, those corners must be sealed by fusion?—I am inclined to think you are right. It had not occurred to me. And a nitrogen atmosphere.

If that were the only difference it would not be much?—No one, I believe, now-a-days attempts to work a lamp in a nitrogen atmosphere.

Because so good a vacuum can be obtained?—So they could then. I think the Sprengel pump was invented before that.

When was the Sprengel pump invented?—I cannot tell. Clearly before 1879, when Edison took out his patent.

However, in that patent (of Lane-Fox) you get a vessel made entirely of glass, containing a wire of high resistance attached to conducting wires, which are sealed through the glass?—Yes.

Why do you assume that the "some suitable material" excludes carbon?—I do assume it, because the man has given you the preference of something which is very different from carbon.

Do you say that, seeing that it was known in 1878, and for thirty years before that carbon was a suitable material?—I should say that in 1878 no human being except Edison knew how to make a carbon filament.

That is not quite an answer to my question.—This man wanted a lamp of high resistance, and all the prior knowledge leads anybody to say that you cannot use carbon, for, whittle it down as you will, it will be a thing, not of high resistance, but of low resistance.

In Scott's patent, 861 of 1878, the inventor says: "My invention consists, first in the following improvements in the manufacture of rods, sticks, blocks, or discs, and hollow cylinders of carbon, to be used in the production of electricity . . . . . My invention consists, secondly, in manufacturing flexible bands, ribbons, or cords, of carbon (or mixtures consisting essentially of carbon) to be used as hereinafter described for the production of light by electricity." The method of manufacture is then given.—I do not know whether you are under the impression that these bands are to be made incandescent; they are nothing of the kind. They are carbon conductor jack towels that run over a roller and carry blocks, and they convey the electricity to those blocks for arc lighting.

I do not say that Mr. Scott intended this ribbon to be used for incandescent lamps for a moment. What I put to you is this: Why should you assume that Lane-Fox had not, as well as other men, carbon in his head when he talked of a thin strip?—For the reason I gave, that as far as I know up to that time nobody had found it out. You refer me to a provisional specification, where a man referred to a conducting ribbon, which is to be uncooked hemp fibres, and you are to take care that you never get the heat so high that those fibres become carbonised.

Suppose you took Scott's carbon, why should not that be used for an incandescent lamp?—I think it could be now; but Scott tells you that you must not carbonise it.

When Mr. Lane-Fox described his wire, or other suitable material, was there not actually in existence a substance of carbon which would have answered that purpose?—No; I say there was not. I say you were expressly told not to carbonise. However, that matter is before his lordship, and it is for him to determine.

Mr. JUSTICE BUTT: It is very difficult for me to suppose that Lane-Fox had carbon in his mind when he made this specification.

Mr. CHARLES: Carbon had been used from 1845 downwards as a suitable material for the conduct of electricity over and over again. Now, in specification 3,470, of 1879, we have Mr. Charles Weightman Harrison stating that he gets his flexible carbon by using threads or filaments of silk, or other carbon of flexible and suitable material, and treating them in the manner he describes.—

Making them into strands and winding them together. The object of a man having an arc light in view was to get rid of the difficulty, that an arc lamp can only continue alight as long as the stick lasts, and if he could make his sticks flexible and put them on a roller he could keep his arc light alight a great many hours.

The point is that the manufacture of carbon filaments is not a novelty.—He does not appear to me to do anything except use a filament for the purpose of carrying the carbon.

It has been pressed upon us that the conspicuous merit of this invention is the manufacture of this carbon filament. What I am upon now is that the question of carbon filament was well known before, and that the manufacture of it was well known.—To my mind this is not carbon filament in the sense in which Edison's is carbon filament. A strand of carbon would not to my mind suggest that you might take one thread out of it and use it to advantage for incandescent lighting.

There is no reason why a filament of silk or other material as prepared by Harrison should not be used for an incandescent lamp?—Yes; it would burn.

What, in vacuo?—He says you are to treat it with an acid such as sulphuric acid in order to render it easy to burn.

Do I understand you to say that it will burn in vacuo?—I do not know; that is a difficult question. But your suggestion is that the thing should be carbonised in the lamp. This filament is a non-carbonised filament.

Suppose you pass an electric current through it in vacuo, what would be the result?—It would fall to pieces; that is my notion. You are putting into the vacuum that which has not before been subject to heat, and I think the effect would be that it would fall to pieces.

There is another patent of Lane Fox, November 14th, 1878, 4626, in which he says: "In order to obtain light from an electric current I make use of a sheet of platinised or iridised or carbonised asbestos or other suitable material, supported between two conducting terminals of platinum or other suitable material, and in order to preserve the incandescent substance in a good condition and to prevent its deterioration I enclose the whole in a glass or other suitable transparent vessel or cover, through which the platinum supports are fused. This vessel or cover is then exhausted of air by means of a small tube leading from it, and it may then, if thought desirable, be filled with some gas or vapour which has no action on the material used for producing the light." He does not treat it as essential at all that there should be any other gas or vapour. He says, as in a former patent, that it may be if thought desirable. "When platinum, iridium, iron or other metal is used either pure or alloyed with some other materials, and either plain or covered with some suitable material, such as powdered asbestos, magnesia or vitreous substance, I prefer to coil a long strip or wire into the form of a spiral and to attach the two ends to platinum wires fixed side by side by fusing into a piece of glass or otherwise, so that they are parallel to one another, one wire carrying the top of the spiral and the other the lower end. The length and thickness of the spiral will depend on the intensity of the light required and the electromotive force available. The ends of the spiral should be united to these wires with some hard solder. This spiral is then enclosed in a globular or flask-shaped glass vessel, whose neck is sufficiently large to admit it, and the neck should then be closed up around the two supporting wires, so as to seal them in and make the whole vessel air tight. A small tube projecting from some part of the neck is then connected with a Sprengel air pump or other exhausting apparatus, and the air is then removed as completely as possible and the tube sealed up, some gas being previously admitted if desired into the vessel as before described. The neck of the vessel may be fixed to some suitable holder or support, and the projecting platinum wires should be connected to proper terminals. According to another method or arrangement for obtaining light by the incandescence of carbon or other suitable material, the said material is enclosed as before described in a glass vessel from which the air is exhausted, or which is filled with any suitable gas, and the terminals are as before described fused into the glass at the lower end of the neck where it is sealed up; or the glass vessel may be made in any way in which it can be readily opened when desired and be again hermetically sealed; one of the terminals leads by a proper conductor to a small piece of hard coke, graphite or other suitable material, and is fixed thereto so as to be in good electrical contact with it. The piece of carbon may be spherical or of other shape." There we have both arrangements, the arrangement of a strip or wire in a coil, and we have this further method or arrangement where the glass vessel is sealed up in the manner described. There at any rate I find, do I not, a disclosure of a combination consisting of a glass vessel hermetically sealed with the conducting wires sealed through the glass?—Yes, I think so.

And further generating light inside this glass vessel by means of the incandescence of the carbon?—Again, it is one of those semi-incandescent lamps. You will find when he comes to the carbon, from the information he gives, it is clear it is not a lamp to be made by incandescence, because you are to use a small piece of hard coke or graphite or other suitable material. It is to be in good electrical contact. Then you stop. The specification goes on: "The other terminal leads to the bottom of a long cylindrical vessel containing mercury; in the mercury is a float of some conducting material capable of vertical movement and attached to a metallic wire or rod passing through and fitting into an aperture or guide at the top of the cylindrical vessel; to this wire or guide is fixed a long pencil of carbon $\frac{1}{16}$th of an inch thick; this carbon being fixed to the rod of the float, is pressed upwards by the buoyant action of the mercury, and the upper end of the pencil is thus pressed lightly against the lower surface of the piece of carbon or material above-mentioned, so that by passing the electric current through the two terminals a brilliant light is emitted at the point of contact of the two carbons or materials. If the pencil wears away it is by virtue of the float and guide retained in the proper position, and presses with an equal pressure against the carbon or material above." This is simply a repetition of one we had before with the copper tube.

In specification 1122 of 1879, of Lane Fox, have we not the combination which we find in Edison's patent, with the exception that a different mode of manufacture is given for the carbon bridge used?—Yes, you have everything there but the carbon filament.

Tuesday, May 11th, 1886.

Sir FREDERICK BRAMWELL, recalled, observed that he should like to state at the outset that he was a shareholder in the Edison Company. In further cross-examination by Mr. Charles, he said metallic spirals were known before 1879. Chauvin spoke, in his patent of an "electric submerged lamp," of a platinum thread rolled into a spiral and fixed by a screw to two metal rods.

Mr. CHARLES: Let me call your attention to page 263 of Fox's specification, No. 3,988, line 19, where he says: "Instead of stretching a strip of leaf or foil between two conductors, as already described, I sometimes coil a long strip of foil into a kind of spiral shape, having a tube of talc, glass, fire-clay, steatite, or lime within the spiral and one of talc, or glass, just covering it outside. A fine platinum wire may be used instead of a strip of foil, but the foil is preferable. A chief object I wish to obtain in this lamp is to prevent as much as possible the dissipation of force in the form of heat and to concentrate and intensify it in the form of light."—Yes. You see there he puts the coil on a core, as it were, of some material, and he absolutely proposes to enclose it in a glass with the object of preventing dissipation of heat. He does not appear to have seen that the coiling it into a spiral and leading the inner coils to radiate against the outer coils would obtain that object alone.

He says his object is "to prevent the dissipation of force in the form of heat and to concentrate and intensify it in the form of light."—Yes. Two men may have the same object in view, but one man may have a patent for obtaining that object in one way and another in another.

In Mr. Edison's patent, No. 4,226 of 1878, page 4, line 46: "In figure 7 is represented a light-giving body formed of a platina or similar wire, around which carbon is made to adhere by pressure; the same becomes luminous by the action of the electric current." "In fig. 8 the spiral, *a*, is similar to that in fig. 2, but a spring is used as a safety to maintain the electric current unbroken if the wire or coil, *d*, should fuse and thereby break the circuit." There you see in fig. 8 a metallic spiral?—Yes.

Mr. JUSTICE BUTT: There again it is platinum covered with carbon, not a carbon spiral.

WITNESS: As far as I know this patent is one for the purpose of preventing these various filaments from becoming over heated and fusing—self-acting arrangements principally.

Mr. JUSTICE BUTT: Sir Frederick Bramwell has admitted, and it seems to me clear that before this patent in 1879 spirals were known, and it seems hardly worth while going through all the patents unless you get more than that. You now get to a very thin spiral.

Mr. CHARLES: The reason I have been going through them is this, I had some apprehension that if I did not put them to Sir Frederick Bramwell it might be said when our witnesses came to be examined, "You never put that to Sir Frederick Bramwell; he could have given an explanation of it." Now, Stokes's patent is the last to which I am going to refer on this point. "From a battery or magneto machine which produces the electricity, I pass the current of electricity to an apparatus where I attach the conducting wire to a binding post which is insulated, and from here the current goes through a post to which is attached the end of a coil of platinum or iridium wire, or their metallic equivalent, and the other end of the coil is attached to a post through which the current passes, and then to a binding post from whence it is conducted back to the battery or magneto machine, thus completing the electric circuit." The coil referred to is a very thin wire not much larger than a sewing thread?—Yes.

It offers sufficient resistance to the current to create an incandescent heat, which produces a brilliant light. Had not a similar coil of carbon been known before Edison's patent in 1879?—Not to my knowledge.

Mr. JUSTICE BUTT: It appears to me, if I understand it rightly, that it is extremely difficult, if not impossible, to get a carbon coil of the requisite thinness.

WITNESS: That is so. I cannot imagine any carbon coil of the requisite thinness having been made by manufacture out of a piece of existing carbon; and, so far as I know, no one before Edison made the thing into the desired shape and then carbonised it. Therefore to the question now put to me, whether carbon coils had not been formed, I am inclined to say, no. Here the patentee, although he desires to preserve the heat, is about to do it by surrounding this with a glass cylinder with alum between the inside of the cylinder and the wire for the purpose of preventing radiation.

Mr. CHARLES: I call your attention to Van Choate's patent "My invention relates to a novel method and apparatus, chiefly designed for use in electric lighting, but which is also partly appli-

cable for telegraphic and other electrical purposes. My invention relates partly to an improved illuminator or apparatus for developing light from an electric current. The substance or material which I employ to form my illuminator or burner and which is to give the illumination by the action of the electric influence, is composed or formed of asbestos, mica, platinum or carbon, or any combination of them, and such other materials as may be required to give the proper affinity and homogeneousness to the material. These materials are mixed and prepared to form a metallic or semi-metallic material which becomes incandescent under the influence of electricity and gives or forms the illumination, but which, practically speaking, does not volatilise, melt, or fuse under the influence of the electric current. This metallic or semi-metallic substance or material is preferably made into wire or ribbon of proper size and formed into arcs, spirals, or spiral-globe shaped illuminators or burners, or the material may be formed into discs or globes or spirals wound around a central wire or body or into other shapes required to form the light." There you see the inventor does speak of a wire or ribbon of the proper size and formed into a spiral, having described the material as carbon as well as platinum.—As being semi-metallic. I mean this is a provisional specification in which a man is making the vaguest possible statements, amounting to no disclosure whatever. It comes to this: if you can use carbon you may. That is the utmost you can find—the merest sketch, the merest suggestion of an impossibility, it may be, He does not describe how he is going to do it, nor what the result will be.

Mr. JUSTICE BUTT: These materials, of which the carbon is one, are mixed and prepared to form a metallic or semi-metallic material. I do not understand that he proposed to use carbon alone. He has it in his former sentence as if he did; then he says these are part carbon and part metallic.

WITNESS: It appears to be so, my lord.

Mr. CHARLES: At line 16 he mentions asbestos or platina or carbon, or any combination of them.

Mr. JUSTICE BUTT: Then he says these materials are mixed. You cannot mix carbon with carbon very well.

Mr. CHARLES: I will draw the witness's attention to the view I take of it. What the inventor says in line 16, page 2, is this: "In carrying this part of my invention into practice for electric lighting, I first ascertain or determine the number and power of the lights, lamps or illuminators to be used in such circuit. I then ascertain and determine the amount of electrical resistance that will be required at each lamp or point of illumination to produce the electric arc or light; that is to say, the amount of resistance necessary to render incandescent the carbon, metal or other substance used for giving or developing the light." I put it to you that although he does not describe, any more than Mr. Edison does specifically, the mode in which he obtains his carbon, this inventor did contemplate a carbon wire as well as a metallic wire. —If that is the impression it makes upon your mind, all I can say is, it does not convey that impression to my mind. I dissent from your expression, "Any more than Mr. Edison." Mr. Edison does describe how to make it.

Let me refer you to line 54 on page 2: "By the adjustment of the said switch and adjusting piece as to resistances and otherwise the flow or passage of the electric current is regulated to cause the said current, or any desired proportion of the same, to pass either through the carbon, metal or other substance which gives the light on or through the main conductor." Does not that look as if he intended to make his spirals of carbon as well as of metal?—If you were to take that alone you would not have anything like spirals; but it certainly would look as if he intended there to use carbon alone, and there is no reason why he should not do so if he is about to use carbon in the shape of pencils or sticks. But when you come to find out that which he is going to use when he makes the spirals he tells you plainly that is a semi-metallic material. I can find nothing in that specification which would disclose to the public that you could make an incandescent light by means of a carbon filament, carbonised after it was formed into shape.

Mr. JUSTICE BUTT: I suppose the word carbonised is to be taken to mean burnt into carbon; because I notice in some of these things they have used it in one with reference to a wire or pencil which they coated with carbon.

WITNESS: I think there was such an expression used. Certainly I understand carbonised, being turned into carbon. In the great gas industry the ordinary expression in the gas works is "carbonating" the coal, and there is a book kept called the carbonising book.

Mr. CHARLES: It has been used also in one of these patents as applicable to a thing not turned into carbon, but merely mixed or coated?—It runs in my mind that there is certainly one of them which does.

A carbonised filament, that is a filament turned into carbon?—I should say so. Edison says any fibrous vegetable substance which would leave a fibrous residue after heating in a closed chamber.

Mr. JUSTICE BUTT: I do not say Edison misuses the word at all, but that means having the thing in the shape of carbon after the operation?—After the operation. It was in Edison's sense that I used the expression just now.

Mr. CHARLES: In one sense the words carbon wire are a little difficult to understand, although he has constantly used it. Wire to an ordinary man really indicates something metallic.

Mr. JUSTICE BUTT: It does not necessarily, I suppose. But when you speak of carbon wire you clearly mean something with no metal in it.

Mr. CHARLES: The word "wire" is used of carbon wire as well as others.

Mr. JUSTICE BUTT: Edison's word is "filament."

Mr. CHARLES: He uses four words: wire, filament, strip, or thread.

WITNESS: Your Lordship will see the result of the thing when carbonised. When you take up any one of these lamps the filament vibrates. Until then that was attributable only to a metallic wire.

Mr. CHARLES: Does Mr. Edison, in the specification which is the subject matter of these proceedings, tell the reader how to carbonise his material?—No, not to my recollection, except in regard to the third claim, about which you are asking me. He does there, I think you will find, give very special directions how to make your coil non-conducting—a substance or a metal in between to be eaten out by acid; a special mode of doing it.

He in no way says how he has carbonised?—Certainly not. If you tell a man to carbonise a thing you tell him all that is needed.

In the other patent which I mentioned to you at the commencement of my questions to you yesterday, No. 5,127, he did give the most minute information as to how to make this wire?

Mr. JUSTICE BUTT: He has a patent for the very purpose of making it.

Mr. CHARLES: The discovery of this improved method of making it was made by Mr. Edison before the date of his final specification. That is a matter of considerable importance on the authorities. Then when he files his final specification he gives us no information as to how to carbonise.

Mr. ASTON: I beg your pardon. He gives the information in a collateral patent running at the same time.

Mr. CHARLES: No; he does not. It was not running. November 10th is the date of the provisional specification, and the final specification followed on May 10th. Between those dates, on December 15th, 1879, comes provisional specification No. 5,127. This was followed by a final, after the date of the final specification now sued on. He did not disclose this method of carbonising when he filed his final, although he knew it.

Mr. ASTON: Because he had disclosed it in a previous provisional specification for which he had applied.

Mr. CHARLES: That I do not think you will be able to prove. What I say is this, he gave no information whatever for his final as to how to make the filament.—My answer to that is yes and no.

Mr. JUSTICE BUTT: Not as to how to carbonise the filament; but as to how to make it he does.

WITNESS: If a preparation for carbonisation is what you mean by giving no information, then he does give information. If you mean he does not say by carbonisation, "I mean exposing a thing to such a heat that the volatile matters will be driven off and the carbon left," he has not said that in terms, because that is all comprehended in the one word "carbonising."

Mr. CHARLES: Now, I want to ask you a few questions about the Swan. Prior to the discovery of Swan, according to specification 18, of 1880, was it not known that air was occluded in carbon as well as in metal, and also that air thus occluded could be got out by the heat produced by the electric current?—Yes.

Now turn to Edison 2,402, of June 17th, 1879, page 9. "I have ascertained that when wires or sheets of platina, iridium, or other metallic conductors of electricity which fuse at a high temperature are exposed to a high temperature near their melting point in air for several hours by passing a current through them and then allowing them to cool, the metal is found to be ruptured and under the microscope there are revealed myriads of cracks in every direction, many of which are seen to reach nearly to the centre of the wire. I have also discovered that, contrary to the recognised notion, that platinum or platinum and iridium alloy loses weight when exposed to the heat of a candle, that even heated air causes it to lose weight, that the loss is so great that it tinges a hydrogen flame green under the influence of an electric current, and at a yellow white heat the loss is very great. After a time the metal falls to pieces, hence wire or sheets of platinum or platinum and iridium alloy as now known in commerce are useless for giving light by incandescence; first because its loss of weight makes it expensive and unreliable and causes the burner to be rapidly destroyed; second, because its electrical resistance changes by loss in weight and its light giving power by the cracks or ruptures, the melting point being determined by the weakest spot where the greatest difference of potential of the electric current is present, which causes this point to be brought to a higher heat than the rest of the surface of the wire. Again, as it is essential to obtain a steady light the platinum must be screened from the air, and when thus screened by being placed in a glass vessel the glass soon becomes coated with a black deposit of platinum. A platinum spiral brought to incandescence under those conditions may be made to give a light of three standard candles when near its melting point and when the radiating surface is $\frac{3}{10}$ths of an inch, but this amount of light will be rapidly reduced as before described. From my researches and experiments I am led to believe that the cause of the rupturing of the metal when brought to incandescence is due to the action of the gases contained in the pores of the metal. These gases are probably compressed within the pores during the rolling or drawing of the sheet or wire. These gases or air when subjected to high heat are greatly expanded and rupture the metal, and it cannot be driven out by slowly heating the metal. I have also discovered that the loss of weight and apparent volatilisation of the metal is due to the air or gases against the highly heated surfaces. Having thus ascertained the cause of fracture and loss of weight, I have conducted experiments to obviate these

defects, and have succeeded by the following method." The point that we make upon this is that this is the very method which is now applied in Swan's patent, only applied by Edison here to platinum, "A spiral of platinum wire is placed in a glass bulb with its end passing through and sealed in the glass and the air exhausted from the bulb by a Sprengel pump until the discharge from a three-inch induction coil will not pass between two subsidiary wires in the bulb, the ends of which are four millimetres apart; the wires of the spiral are then connected to a magneto-electric machine or battery whose current can be controlled by the addition of resistance, and sufficient current is allowed to pass throughout the wire to bring it to about 150° Fahrenheit; it is allowed to remain at this temperature for 10 or 15 minutes. While thus heated the air or gases in the pores of the metal are expelled by the action of the heat and the expansion of the gases, which tend to pass outward in consequence of the vacuum. While the air or the gases are passing out of the metal, the mercury pump is kept continuously working. After the expiration of about 15 minutes, the current passing through the metal is to be augmented so that its temperature will be about 300° Fahrenheit, and it is allowed to remain at this temperature for another 10 or 15 minutes. If the mercury pump be worked continuously and the temperature of the spiral raised at intervals of 10 or 15 minutes until it attains vivid incandescence, and the bulb be then sealed, the metallic wire is then in a state heretofore unknown, for it may have its temperature raised to the most dazzling incandescence, emitting a light of 25 standard candles, whereas before heating same spiral would only emit a light equal to three candles before reaching the melting point." Now, this invention of Edison anticipates, does it not, the invention of Mr. Swan? I do not suppose he knew it.—That appears to me to be a matter for his lordship. There it stands; I offer no evidence upon it. The only thing I call attention to is that Edison speaks of making the carbon pasty, and that, I think, is certainly a novelty. In so far as that is concerned, I think you will find the Swan lamp does not do it.

The only office of the electric current is to produce the heat?—That is all.

Heat and exhaustion, putting the electric current aside for a moment, were known before that patent of Edison's?—I am not sure whether they were or not.

Allow me to read to you a passage from the Philosophical Transactions of the Royal Society of the year 1876. It is a paper by Prof. Crookes, entitled, "Repulsion resulting from radiation." [Reads.]—There is a clear description there of driving off occluded air from charcoal by exhaustion, accompanied by heat other than the heat of an electric current through it. That will modify my answer.

With reference to the last clause of your answer about the electric current, differing Edison's patent 2,402 from other discoveries. Have you had your attention drawn to a patent of Sawyer and Man, published in England on June 10th, 1879?—Yes; but I have no recollection of it in reference to this matter.

Mr. ASTON: That is an American specification. Perhaps your Lordship will take that subject to the exception that we do not admit that it was published in England at that time.

Mr. CHARLES: I will prove that it was published in England on June 6th, 1879. The part of the patent which deals with the expulsion of the occluded gases is the last page of it, the second paragraph: "To charge the globe we proceed as follows:—The lamp being connected with a hydrogen generator, we first exhaust the air, then we charge the globe with pure dry hydrogen, again we exhaust, charge with hydrogen, and this operation we repeat until the original gaseous contents of the globe are entirely replaced by the hydrogen. We then in place of the hydrogen connect the lamp with a generator of pure dry nitrogen, keeping the globe, *a*, constantly heated by having it immersed in a bath of hot water, exhausting the hydrogen. We fill the partial vacuum with nitrogen, or we may do it by displacement, and this operation we continue until the globe contains nothing but hydrogen, except such gases as may be occluded by the enclosed materials. To drive these out we pass an electric current through the conductors, *x*, *x*." There we find electric current?—There you appear to find the electric current coupled with a combination with an exhaustion pump; but you have already got it in Edison.

Mr. JUSTICE BUTT: There is exhaustion there?—There is exhaustion: whether it really means a fully vacuous condition or replacement, I do not know. It may, or may not. At all events it carries the thing no further than Edison. Whether it carries it as far I am not clear.

Mr. CHARLES: All I want to get before my Lord is that Edison is not the only person who mentioned this matter. The importance of this is that it is in connection with carbon, and, further, in connection with the carbon of an incandescent lamp, and shows heat and exhaustion, and heat produced by the electric current. This was prior to Edison, published in England June 6th, 1879.—It is an incandescent lamp and carbon, and a current through the carbon; but I am trying to see what the whole thing is about. I really do not pretend to know whether the heating is done when the lamp is in an exhausted condition or whether it is done when the lamp is charged with nitrogen, the exhaustion having been afterwards. It may be either the one or the other; it is more for your Lordship than for me.

Mr. JUSTICE BUTT: It may be more for me than for you, but if you do not know what it means, I am sure I should not.

Mr. CHARLES: Prior to the taking out of the patent No. 4,576 was not the plan of moulding carbon with other material known?—Yes.

Such materials, for example, as starch, flour, tar, sugar or pitch?—Yes.

And after moulding the carbon into shape was it subjected to heat?—I think, in some cases, it was.

This moulding of carbon into shapes was for the purpose of using it for electric lighting.—In some instances it was.

One word about Gimingham. Is there anything more in Gimingham's than the application to this platinum of an ordinary mechanical device?—I am sure I do not know. There is a new and useful commercial article, I imagine, produced. Whether that is the subject matter of a patent is not for me. It is a simple and meritorious mode of making a connection between a filament and a wire. If in order for a patent to be valid it involves complexity, I should think that that is a bad thing. The simpler you can make a patent the better, I should say.

Is it anything more than the application to platinum wire of an ordinary and a well-known mechanical device?—No; it is not.

Re-examined by Mr. ASTON: You were asked whether there was any description in Edison's specification of the process of carbonisation, and I understood you to say that as regards that process the description of it was not necessary?—Was not necessary; because it is a well-known process involving heating a material composed partly of carbon and partly of other matters which are driven off by heat when kept free from the action of the atmosphere so that you carbonise and do not burn.

In your opinion is the specification of Edison, No. 4,576, sufficient to enable a person of ordinary intelligence to carry into practical operation this invention?—Yes, it is.

In any one of the prior specifications put to you, do you find Edison's first claim, which is for an electric lamp for giving light by incandescence, consisting of a filament of carbon of a high resistance, made as described and secured to metallic wires as set forth, anticipated?—I do not.

Taking the statements made in these specifications all combined, was what is claimed in the first claiming clause in your opinion a new and useful invention in 1879?—I believe it was new, and certainly it was useful.

With regard to the second claiming clause I put the same question?—I make the same answer.

So with regard to the third and fourth claiming clauses?—I make the same answer.

I hold in my hand an electric lamp [marked "P. 1"] I am told this is a wood splint made into something which connects the two terminals. Is that a carbon filament?—This is the exact kind of construction that I saw being made in the United States in 1882. That is to say, the bamboo filament with the enlarged ends. I cannot tell by looking at this that it is bamboo, but it is exactly like that which I saw in the uncarbonised and carbonised state made out of bamboo filament.

Assuming that that material which you see there is made out of bamboo fibre, is that a carbon filament within the meaning of Edison's specification?—Speaking as a mechanic, I should say so, certainly. It is a vegetable. You get these words here:—"Fibrous vegetable substance which leaves a carbon residue after heating in a closed chamber."

In Edison's specification 4,576, page 4, line 40, he speaks of various materials that may be employed in these words:—"I have carbonised and used cotton and linen thread, wood splints"—that would include bamboo, I suppose?—Yes.

"Paper coiled in various ways, lamp black, plumbago and carbon in various forms mixed with tar and kneaded so that the same may be rolled out into wires of various lengths and diameters." Those would not be fibrous, I presume?—I presume not.

As far as you know, would they answer equally well if made in the way described there?—I only know it from information, not from my own knowledge.

As a mechanician, do you see any reason why they should not answer?—No; I can understand its being more a guarding claim to prevent the mode being infringed, than the mode the patentee would ordinarily adopt when he has such a simple plan as this.

Now, upon this matter of manufacturing the carbon filament. Your attention was called to a subsequent patent applied for by Edison, the date being December 15th, 1879. At that time the provisional specification of the patent 4,576 of 1879 was, as it is commonly called, running?—Yes; No. 4,576 is dated November 10th, and No. 5,127, December 15th.

In the provisional specification of 4,576 there is no reference to any particular method of carbonisation as forming part of the patent for which Edison was making application?—I do not think there is. I do not remember.

You said, I think, that that was a further improvement upon the patent 4,576?—Yes; I think I said that it was a kind of improvement a man makes when he begins to work a thing upon a commercial scale, in order to do the operation with economy and rapidity.

Is it not a common practice to take out patents for improvements, the further improvements being patented during the running of the substratum patent?

Mr. CHARLES objected to the question. It was not a scientific question.

Mr. JUSTICE BUTT: Supposing it is not a scientific question. The question is, may we have the fact from one who knows the fact, apart from its being scientific?

Mr. ASTON said he would not press it.

Mr. JUSTICE BUTT did not think it could have any effect either way.

Mr. ASTON (to witness): Do you see anything kept back by

Edison which would prevent his invention being carried into practical operation?—Nothing.

Sir RICHARD WEBSTER intimated that Mr. Charles had not cross-examined upon the question of infringement, and said that if there was anything else he thought it should be indicated to Sir Frederick Bramwell.

Mr. CHARLES: I would ask one question of the witness. In that lamp which you hold in your hand is the carbon filament secured to the metallic wires in the manner set forth in Edison's patent?—I think not. I think it is secured in the manner of Gimingham. I have not broken one of these lamps, and I could not answer.

Dr. JOHN HOPKINSON was next called. Examined by Sir Richard Webster, he said he had studied scientific matters for twenty years and for twelve years had made electrical matters his special study. Amongst other things, he had been adviser to the Edison Company. He had carefully considered the three patents which were the subjects of this action, and the alleged anticipations. He agreed with the opinion in regard to the detailed matters mentioned which Sir Frederick Bramwell had given in his evidence. In Edison's specification the electrical combination was a conductor of carbon of small cross-section, consequently of comparatively high resistance and properly called a filament, and prepared in a particular way. The ends of this filament were attached to metallic wires for the purpose of conveying the current to it, which wires were sealed into the walls of a glass receiver so that the filament was entirely enclosed by the receiver, from which the air was exhausted so as to produce as good a vacuum as possible. The particular way of manufacturing the filament which the patentee described, consisted in taking a flexible body capable of being reduced to carbon, giving that body the desired form, and then reducing it to carbon by subjecting it to high heat in a closed chamber. The first claim of the specification, as he understood it, claimed the carbon filament made in the particular way that Edison had described, with the conducting wires to which it was secured for the purpose of forming an incandescent lamp. The second claim was for the combination of a carbon filament with the receiver entirely of glass in which the conducting wires were sealed, and from which the air was exhausted. The third claim referred simply to the particular shape which might be given to the filament for the purpose of steadying the light. The fourth was for a particular method of securing the platina contact wires to the filament, namely, by covering the junction with plastic, carbonisable material and then carbonising the whole. Each of these combinations or devices was new at the date of Edison's patent. Both fibrous and non-fibrous materials were mentioned as the constituents of the conductor before carbonisation. The filaments of the Edison lamps, which were largely used in England, were made of bamboo fibre. It was undoubtedly a perfectly useful and effective commercial lamp. One of the earliest installations put up by the Edison people when they first came over here was at the House of Commons.

Mr. JUSTICE BUTT: They tried it, and they took it away.

Sir RICHARD WEBSTER: Your Lordship is speaking of the main House of Commons, and I am speaking of the dining room.

WITNESS: And in the case of the House itself it was lighted with the arc lamps.

Mr. JUSTICE BUTT: They made the ceilings and curtains and everything so dirty.

Sir RICHARD WEBSTER: As a matter of fact these Edison lamps are used all through the House of Commons at the present time, and the Swan lamps as well; not, of course, in the House itself. (To witness:) Will you tell me in your own way what you think was the great improvement in this combination over the previous knowledge?—The great improvement was in obtaining a method by which a carbon conductor of high resistance and small section, or small surface, could be produced. It is important, in order to have small lights of high efficiency, that the total superficial area of the carbon conductor should be small. With the exception, perhaps, of one or two cases, all incandescent lamps made since the publication of Mr. Edison's patent have practically been carbon conductors of small section.

Sir RICHARD WEBSTER: Apart from the theoretical and book knowledge of the matter, what do you say as to the practical result of this invention? Was incandescent electric lighting practicable before this invention?—No; at this date there was a marked discontinuity in electric lighting. Immediately after, incandescent lighting became an important industry, and, in America, in England, all over the Continent it has gone on developing and extending to an extent which, having regard to the shortness of time, is most surprising; and dependent industries have developed at the same time.

Do you know of any previous disclosure of the shaping of a carbon filament prior to carbonisation for electric lighting?—No.

You are aware that the flexibility of the filament before carbonisation is spoken of by Mr. Edison in his specification?—I do not remember whether he puts it in those terms, but it is implied.

Does that flexibility continue after it has been carbonised?—Yes; but in a less degree.

Is that important from a commercial point of view?—It is of value. The filament is less liable to be broken by mechanical shocks, and, further, it is less affected by expansion due to variations of temperature.

Will you kindly look at the lamp marked "W. & R." Do you find there Mr. Edison's combination as you describe it?—Yes; I find here a filament which is apparently of carbon, attached to metallic wires. How it is made I cannot tell, but I know of no other way of making it than that which Mr. Edison describes. The wires are sealed into a receiver entirely of glass; and I have, practically, no doubt whatever that the air is exhausted from that glass receiver.

Will you tell us the leading points of what was known prior to 1879 with regard to incandescent electric lighting. First, what conductors were known?—Thick sticks of carbon were known, both in vacuo and in gases which would not oxidise carbon, such as nitrogen. Then wires of platinum and platinum iridium were known; both these had been employed with what we may call, perhaps, a laboratory success. Then there had been proposals to use various mixtures of conducting and non-conducting materials, such as asbestos mixed with carbon, and such like, and wires covered also with materials like asbestos, and so on. I do not know that they ever attained what would be called even a laboratory success. So far as I know they never got beyond the paper stage.

One word as regards vacuum. Had that been attempted before?—Yes. The carbon sticks had been used in vacuo, and Mr. Edison himself had used metallic wires in vacuo.

Do you believe that was the extent of what had been disclosed by the prior specifications?—Yes.

Do you find in any one of them, or in the whole taken together, an enunciation of Mr. Edison's combination, or the parts which have been referred to in these several claims?—No.

In the provisional specification of Mr. Lane-Fox, No. 4,626, there is described a floater in mercury. Was that anything like Edison's incandescent lamp?—Oh, no. It works on an entirely different principle.

(To be continued.)

JUDGMENT.

Thursday, May 20th, 1886.

The trial of this case terminated on Wednesday evening, and Mr. JUSTICE BUTT delivered judgment yesterday (Thursday). We shall give a verbatim reproduction of the judgment when the proper stage of the proceedings is arrived at in our detailed report of the case, and content ourselves now with placing before our readers an abbreviated account which will put them in possession of the main points on which the judgment was based.

His LORDSHIP, having remarked that at an early stage of the proceedings he intimated that there was no evidence of infringement of the Swan and Gimingham patents, and that therefore the validity of those patents was beyond the sphere of the present enquiry, proceeded to deal with the Edison patent. There was one fact beyond contest, he said, namely, that before the date of Edison's specification no good and efficient incandescent electric lamp was made or known. He accepted, without hesitation, because it was also accepted by all the defendant's witnesses, Sir Frederick Bramwell's compendious description of Mr. Edison's invention, viz., that it is a vessel made entirely of glass, containing a carbon filament attached to conducting wires, the wires being sealed through the glass and the vessel exhausted of air to a very great degree. The defendants denied the validity of the patent, and also denied that they infringed it. He had all along been of opinion that there had been no infringement of claims Nos. 3 and 4 in Mr. Edison's specification; and he now also thought there was no infringement of claim No. 1, but in the view he took of claim No. 2 that question became unimportant. The question of the infringement of claim No. 2 depended on the meaning to be attached to the words "a carbon filament." If these words meant a carbon filament "as described" in the patent, he should hold that there was no proof of its infringement; but he did not so interpret these words. He held them to mean any carbon filament, however made, which possessed certain qualities or properties mentioned in the specification, or necessarily resulting from the description there given; to answer that description the carbon filament must possess flexibility and resiliency, must be of small cross-section, offering a high degree of resistance to the passage of the electric current, and must present but a small surface from which radiation of light could take place. He was disposed also to think, but refrained from giving a decided opinion, that the degree of resistance must not be less than 100 ohms. Taking this interpretation as correct, it was clear there had been infringement by the defendants. Taking Mr. Rawson's evidence, in which he said the defendants used carbon filaments, connected at the ends with platinum wire, in a vessel made wholly of glass, the leading wires passing into and from the receiver being sealed into the body of the vessel, and the air being exhausted to get as good a vacuum as possible; and that the carbon filament used was flexible and as stable at high temperatures as it could be got, but that it was not made by Edison's process—taking that evidence, and applying his interpretation of the words carbon filament, there was an infringement of the patent. But it was said, assuming the infringement, the defendants are not liable, because the patent is invalid. The first reason in support of the invalidity was, that "a carbon filament," when taken to mean what he had held it to mean, was a description too vague and indefinite, or, to use the Solicitor-General's words, was too large. That was an argument to which he could not accede, for he saw no reason why a carbon filament having the properties mentioned in Edison's patent, and which the patentee told the public how to make might not properly be the subject of a patent, although it was capable of being made by methods and of materials others than those set forth in the specification. Secondly, it was said that the specification was not such as would enable the competent

workman to make the lamp. The plaintiff's witnesses had stated that in their opinion it would enable him to make the lamp, and Dr. Odling practically admitted the same thing. He held, therefore, that the evidence established that the specification was one which would enable the competent workman to make the lamp. It was next said that a lamp made according to the specification would not be a good lamp; so said some of the defendant's witnesses, but the plaintiff's witnesses gave evidence to the contrary, and the Solicitor-General expressly stated that he did not dispute the utility of Mr. Edison's invention. Under those circumstances he came to the conclusion that a sufficiently good lamp might be made under the specification. Fourthly, it was said by the Solicitor-General that the patent was invalid, because at the time of the final specification Mr. Edison himself knew of a better method of making the filament than that described in the specification in question, and in support of that proposition his provisional specification of December 15th, 1879, No. 5,127, was referred to. The argument was that he ought to have disclosed the new method in his final specification, which was dated May 10th, 1880, because a patentee is not entitled, on the authorities, and as a matter of good sense, to withhold from the public a discovery of which he is aware, forming an important integral part of his patent, and then take out another patent afterwards for it. So to do, would be to put the public to the inconvenience and expense of taking out a license to use two patents, whereas they ought to have had the whole user by taking out a license for one. It must, however, be borne in mind that Mr. Edison did not claim in his patent 4,576, for the manufacture of the carbon filament, but for the union of a carbon filament possessing certain properties with the other parts of his combination. There was no evidence that at the time of filing his provisional specification 4576, he had discovered or knew of the process described in patent No. 5127, and he agreed with Mr. Aston, that an inventor had no right to put into his final specification as part of his invention a discovery which he had not made and of which he was ignorant when he filed his provisional specification. He thought, therefore, that the contention on that head could not avail against the plaintiffs. But further it was alleged that the invention was not new. A number of specifications and publications anterior to the date of Mr. Edison's patent had been adduced as describing either the separate parts of Mr. Edison's combination, or something very like them. But the evidence showed that no one of those publications, unless it were Swan's, contained the combination described by Mr. Edison. In Pulvermacher's specification, which was typical of the others, was a carbon rod or thread, which, if taken by itself, was very like Mr. Edison's coiled carbon filament, mentioned in claim 3, taken by itself. But it was used by Mr. Pulvermacher in a totally different way, and for a totally different purpose. It was curious that Mr. Pulvermacher's patent dealt with two modes of lighting, the arc and the incandescent; and it was very remarkable that, having described in detail the spiral rod or thread for the purpose of the arc light, when he came to state what was his mode of procuring an incandescent lamp, he discarded his carbon conductor altogether, and resorted to metallic wires. Whatever the likeness between Pulvermacher's spiral rod and Edison's coiled carbon filament, it was perfectly clear to his mind that Pulvermacher was wholly unaware that the coiled thread of carbon could be applied to the purposes of incandescent lighting. With regard to Lane-Fox, it seemed to him that the Solicitor-General was perfectly warranted in saying that it was abundantly clear from the different specifications of Mr. Lane-Fox that he had realised and knew all the elements that were necessary to make a good incandescent lamp; but it was also true that when he came to prescribe what he would use in his own invention he nearly always seemed to revert to metallic wires for his conductor. He did mention a carbon conductor in one or more of his specifications, but, like Mr. Pulvermacher, when he came practically and finally to deal with the matter, he disclaimed it and it dropped out of his patent, evidently because he did not know how to make an efficient carbon conductor. Passing over the other matters, he now came to the alleged anticipation by Mr. Swan, whose lamp was the only combination at all like Mr. Edison's. Other men of science might have described individual parts of the combination, but none of them had brought all those parts into combination like Mr. Edison had. The law, he took it, was clear. Each individual part of the combination may have been known before, yet if the combination of those parts be new, the combination may properly be the subject of a patent. But it did appear to him that if Mr. Swan's conductor was practically the same thing as Mr. Edison's carbon filament, then they had in Mr. Swan's lamp the whole of Mr. Edison's combination, and that before the date of Mr. Edison's specification. The main question, therefore, was, were Swan's carbon rod or pencil and Edison's carbon filament practically the same thing. He thought they were not. It was a question of interpretation, and, *prima facie*, no doubt the meaning of words in a written contract was for the judge. But where technical terms, words of art, were used, the evidence of scientific witnesses and experts in the matter to explain the sense in which they were used might be received. Accordingly each side had called a certain number of scientific witnesses, to whom had been put the question of the meaning of the words "a carbon filament" in claim 2. The plaintiff's witnesses said that Mr. Swan's carbon rod or pencil was not only different from Mr. Edison's carbon filament, but it was totally and wholly different: the defendant's witnesses said the two things were identically the same. In these circumstances he must draw such conclusions on the point as his own uninstructed light would enable him to arrive at. To his mind it seemed that the carbon pencil or rod was a very different thing from the carbon filament. Mr. Edison's conductor possessed a smallness of cross-section combined with other properties which Mr. Swan's did not. Mr. Edison's conductor possessed a degree of flexibility which was not even approached by Mr. Swan's. Dr. Odling said that in Mr. Swan's lamp the conductor was a rod, but it was a filament too; and in support of this referred to a communication by Mr. Swan in January, 1882, in which he called his conductor a filament. But this, as a matter of anticipation, rather broke short in Dr. Odling's hands, because instead of being an anticipation it was about a twelvemonth after the event. He could not help thinking that if Mr. Swan at an earlier period, before Mr. Edison's specification, had known of the various advantages of Edison's carbon filament, as used, his lamp would never have contained a straight rod fixed at each end to platinum wires. Moreover, there was no evidence to show that before Mr. Edison's specification he knew how to make a carbon conductor of anything like so small a cross section, and which would answer the other requirements stated. The first time he found Mr. Swan's conductor spoken of as a filament was in his final specification of the patent which formed one of the matters of this suit, and that was under the date of July 1st, 1880, Mr. Edison's final specification being seven or eight weeks prior to that. Having the advantage, if he had chosen to use it, of the knowledge conveyed to the public by Mr. Edison's specification, Mr. Swan, some weeks later, called his carbon conductor a filament. A rose did not smell any sweeter for being called a rose, and the fact that Mr. Swan had subsequently called that rod a filament, did not at all convince him that it was properly so called. He did not forget that it was in evidence that electricians had adopted the word filament, and applied it to all manner and kinds of carbon conductors in incandescent lamps. Words often became, when applied to particular trades or sciences, twisted from their original meaning. A dozen at one time meant twelve, but he was not quite clear what it had not been held by the courts in particular trades; it certainly in many did not mean twelve or anything like twelve. So with regard to these matters. An illustration was given by means of a very beautiful flower, a tulip he believed, and he was referred to that portion of it which held and supported the anther as a filament, and he was told that in botany that was universally recognised as the filament, of whatever size it might be. That might be. It had acquired that name in botany just as these conductors had since amongst electricians acquired the name of filament, but he suspected it would be found that they had acquired the name of filaments since flexibility was introduced and rigidity tabooed. On the whole, he had therefore come to the conclusion, firstly, that there was no sufficient reason for saying that this patent was invalid on any of the grounds suggested on the part of the defendants, amongst others, of course, that there was no ground for the assertion that it had been anticipated, or, in other words, that it was not new. In the next place, he held, attributing the meaning he had given to claim 2, that there had been a clear infringement by the defendants in their lamp. That being so, the decree he must give was that those of the plaintiffs who possessed the legal and beneficial interest of Mr. Edison's patent, that was to say, his assignees, were entitled to the plea. With regard to the other plaintiffs, of course the action would be dismissed.

Mr. ASTON asked for a certificate that the validity of the Edison patent came into question; for an order for an account of the profits made by the defendants by the sale of the articles in question; and for costs on the higher scale.

Mr. JUSTICE BUTT having acceded,

Mr. CHARLES applied for a stay of execution pending the appeal.

Sir RICHARD WEBSTER opposed, and pointed out that a final judgment having been given it was not competent for the judge to suspend execution.

Mr. JUSTICE BUTT, although unwilling to press harshly on the defendants, and desirous of forwarding them on their way to the Court of Appeal, held that he could not grant the application made in their behalf.

Mr. ASTON stated with regard to the lamps in the possession of the defendants that although the plaintiffs were entitled either to the delivery to them of those lamps or their destruction, probably an arrangement would be arrived at between the parties as to the course to be adopted pending the appeal.

The Royal Aquarium, Westminster.—The Royal Aquarium, Westminster, has now been lighted for four months by the Gülcher Electric Light and Power Company, Limited. The installation consists of 23 Gülcher arc lamps; in addition to which, Messrs. Bertram and Roberts's dining rooms are lighted by 20 C.P. incandescent lamps. The current for working the installation is obtained from three No. 4 Gülcher dynamo machines placed in an engine house by the side of the hall, to which persons desirous of obtaining information can have access. The motive power for driving the installation is obtained from one of Messrs. Robey's 16 H.P. engines, which has given great satisfaction, and runs with great regularity of speed.

NOTES.

Electric Lighting in the City.—On Wednesday, the 12th inst., the magnificent halls of the Drapers Company were lighted for the first time by electricity, the work having been carried out by the Electrical Power Storage Company. There were 212 incandescent lamps used, of 20 candle-power.

The Electric Light and the new Town Hall at Portsmouth.—It is probable that the electric light will be made use of in the new Town Hall which is shortly to be erected at Portsmouth at a great outlay of money. The matter was mooted at a recent council meeting, when the Chairman of the Town Hall Committee, in reply to a member, said that he saw no reason why arrangements should not be made for using the electric light as well as gas.

Temporary Lighting.—At the representations of the Greek Plays which took place at Prince's Hall, Piccadilly, last week, the electric light was used to great advantage. The temporary installation was designed and successfully carried out by Mr. Montagu Scott. E.P.S. accumulators were used.

The British Association Electric Lighting.—The Gülcher Electric Light and Power Company, Limited, has secured the contract for lighting Bingley Hall, Birmingham, during the Association meeting, to be held in September. The installation is to be carried out under the direction of Mr. Henry Lea, the consulting engineer, and will be of a very complete nature. The interior of the hall is to be lighted by 28 3,000-C.P. Gülcher arc lamps, each fitted with the company's improved raising and lowering apparatus. Old Birmingham, which, it is anticipated, will form a very attractive part of the exhibition, will be lighted by 160 incandescent lamps, suspended either by flexible pendants or upon suitable fittings. The current for driving the 28 lamps and 160 incandescent lamps will be generated by four compound-wound Gülcher dynamo machines, of the latest and most improved type. Three machines will be in actual work, the fourth being used as a spare in case of accident. The motive power for driving the installation is to be provided by Messrs. Tangye, Limited, Birmingham; and the London and North Western Railway Company supply the steam from a locomotive boiler, lent for the occasion.

The Electric Light at Brighton.—The Fifth Avenue Hotel, which is situated near the Aquarium, is rendered conspicuous at night time by the electric light with which the entrance is illuminated.

Bazaar Lighting.—The Gülcher Electric Light Company supplied the plant for the electric illumination of the Shrewsbury Music Hall, during the bazaar given by the 1st Shropshire Rifle Volunteers.

Important to Telephonists.—Mr. Jerome Carty, of Philadelphia, has arrived in London, and is staying at the Hotel Métropole. Mr. Carty is representing the Government of the United States for the purpose of obtaining evidence to be used in the suit by the Government to annul the Bell patent.

The Telegraph in Siam.—It is announced, according to a telegram from Calcutta, that the telegraph line from Moulmein to Myaddy, which is the British section of the Moulmein-Bangkok telegraph, was completed on March 25th. The Siamese Government is vigorously pushing on the work in the section from Rabeng.

Telephonic Communication v. Signalling.—The signalling arrangements between the Commander-in-Chief at Portsmouth (Admiral Sir George Willes, K.C.B.) and the ships and departments under his control have undergone considerable alteration. The telephone has to a very large extent superseded the semaphore, and arrangements of a similar nature are in course of completion by which communication with the ships at Spithead will be very greatly facilitated.

The Extension of the Telephone.—Telephonic communication has now been completed between Glasgow and Ayr, and tests of the wire were made on Friday last. The results were most satisfactory, and even beyond expectations. Voices could be distinguished as plainly as if the speaker were but a half a mile distant. The only drawback is that the wire being so long is apt to collect various sounds along its course, and to one not accustomed to them these sounds are confusing. Although the wire is now completed, it will not be opened to the public until the 25th of this month.

Long Distance Telephony.—In the discussion which ensued at the Society of Telegraph Engineers' meeting on Mr. Preece's paper, Professor Silvanus Thompson remarked that he thought the receivers for the purpose too sensitive and the transmitters not sufficiently powerful. We have on more than one occasion said the same thing; a comparatively insensitive receiver would not be so affected by extraneous interferences, and good speaking could yet be obtained by using transmitters which would throw a stronger current upon the line.

Telegraph First Summer Meeting.—[*Report from our own special tout in Paris.*]—Cable Stakes.—By the list of weights just published I see that the English horses, without an exception, are very heavily penalised, indeed far in excess of what their previous records would seem to justify; the English filly "Miss Manage," bred from the celebrated stallion "Government," has, however, been backed to some extent for a place. Strong opposition has been shown as a rule to the representatives of the Herring Pond stable, for it is rumoured that the Republican course does not suit the "Markis," and that "John" has gone wrong in his trials. There has been a little wagering about "Careful Jamie" and "The Lawyer" coupled for a place, and a few speculators have taken advantage of the long odds offered against these horses. There has been a general rush to back the French bred colt "Radical" (also a descendant of "Government"), and this promising young 'un will probably win, unless it turns sulky or bolts, for its unfortunate temper is well known.

Is this our Correspondent "Bonco?"—Mr. Armstrong, of 6, Milner Street, Chelsea, was summoned last week for assaulting Dr. A. V. Shaw, who described himself as an electrician, of the same address. Mr. T. D. Dutton appeared for the complainant; and it appeared that he had been for some time suffering from nervous excitement and had to be medically relieved. A dispute arose respecting the rent payable, and the allegation for the complainant was that he was pushed off the front doorstep, after the chain had been put up against him, and was nearly thrown to the ground. The defendant denied that he had touched the complainant, who was of very peculiar temperament, but could give no explanation for the push at the front door. Mr. Dutton pressed for a penalty, in order that the complainant should be vindicated in the action he had taken, and Mr. D'Eyncourt fined defendant 5s., without costs.

Secondary Generator Installations.—We understand that Messrs. Ganz & Co., of Buda-Pest, the manufacturers of the Deri, Blathy, and Zipernowski secondary generators, have opened a London office at No. 4, Westminster Chambers, Westminster, with the view of undertaking electric light installations in this country.

New Publications.—Messrs. Whittaker & Co. and Messrs. Bell announce in their new "Series of Handbooks for Practical Engineers" Dr. Jul. Maier's book on "Arc and Glow Lamps." It will be a complete handbook on the subject especially relating to its applications, giving the latest results and improvements. The next volume in the same series will be Mr. Gisbert Kapp's "Electric Transmission of Energy," which is promised early next week. Mr. Wm. Anderson has revised and added some new matter to his "Lectures on the Conversion of Heat into Work," which excited so much attention when delivered last year at the Society of Arts. They will be published in book form by Messrs. Whittaker & Co.

Electric Signalling.—The committee which has been sitting at Keyham for some time past, under the presidency of Admiral Sir William Dowell, for the purpose of inquiring into the important subject of day and night signals in the Royal Navy are still engaged in their deliberations. They have made considerable progress in formulating what is believed to be a far more perfect system than that at present in vogue, and early next year will present a most complete and exhaustive report on the subject. There are many difficulties with which the committee have to contend, and not the least prominent amongst them is that of signalising in action. The experiments already made as to the method of the fixed radial arms, lighted up with the incandescent light, and the ordinary semaphore arms lighted in the same manner, have tended to prove the superiority of the old-fashioned movable arms illuminated by the electric arc.

Electricity in the Royal Navy.—Commander Crawford J. M. Conybeare, representing the Admiralty, has arrived at Devonport, for the purpose of making arrangements for the fitting of the *Espiegle* with the electric light. Instructions have been received at the different dockyards that in future all vessels being fitted out shall be supplied with the electric search light. This is an extension of the order issued some time since, and which applied only to the larger class of vessels. The authorities at Chatham have received a drawing from Whitehall for their information and guidance in fitting the electric light on board the turret ship *Warspite*. The system employed is to be the same as that carried out so successfully on board the *Imperieuse* at Portsmouth, and since utilised on various other vessels. Captain S. Long, of the *Vernon* torpedo schoolship at Portsmouth, and Captain A. H. Markham, late in command of the same vessel, have visited the *Warspite* with the view of making the preliminary arrangements. The same officers afterwards visited the *Monarch* and arranged with the Dockyard officials for the completion of the electric light fittings which were temporarily made when the vessel was hurriedly fitted out last year to join the Channel Squadron.

Messsrs. Blakey, Emmott & Co.—We are informed that this firm has appointed Mr. F. M. Rogers, of Finsbury Pavement, E.C., as London agent for electric light machinery, &c.

The Society of Telegraph Engineers and Electricians.—The next meeting at 25, Great George Street, S.W., will be on Thursday, May 27th, 1886, at 8 p.m. The papers to be read are :—1. "The telephone as a receiving instrument in military telegraphy," by Captain P. Cardew, R.E., member. 2. "On a problem relating to the economical electrolytic deposition of copper." By Captain H. R. Sankey, R.E., member.

The School of Electrical Engineering, Hanover Square.—The following notice, with reference to the Easter examination (Mr. H. R. Kempe, chief examiner) of this school has been posted on the notice board :—"May 13th, 1886,—The final report of the Examiners has been just received. I have to announce that the full certificate of the school has been gained by the following students (in alphabetical order) : Léon Drugman, E. Celso Mozzoni, P. S. Tasker, A. A. Voysey. The following gained more than 60 per cent. of full marks, but, with the utmost leniency, could not be brought up to the 70 per cent. necessary for certificate : J. B. Beith, W. T. March, E. Payne, F. L. Todd.—W. Lant Carpenter, Manager." In conducting the examination the papers of the candidates were all numbered, so that no names should be known.

The Daniell Battery.—It may not generally be known that 1886 is the jubilee year of the invention of the Daniell battery.

A Projected Observatory.—The Austrian Meteorological Society proposes to erect the highest observatory in Europe on the "Sonnblick" peak in the Tyrol, 31,000 feet above the sea level. The observatory is to be fitted with the best instruments, and is to be connected by telephone and telegraph with the lower world, so that daily observations may appear in the Austrian evening papers.

Henley's Telegraph Works.—The fire which occurred on these premises on the 16th inst., will in no degree interfere with the course of the company's business the building destroyed being a storehouse situated some distance from the works.

Cable Conference.—The conference is expected to conclude its labours this week, and meanwhile the telegraph companies represented are drawing up a report, which will probably assume the form of a protest against the action of the Governments in a matter of so great moment to the former, and of so little pecuniary interest to the latter.

Submarine Cables.—The *Glasgow Herald* in a leading article upon the International Conference for the protection of submarine telegraph cables makes the comments below :—"Not only do the wires by which our communication with the East is maintained pass under the sea, where they may be interefered with by hostile vessels, but in many cases portions of them pass through the territories of foreign Powers which may or may not be friendly. We can do much to protect our submarine cables from danger, but in the case of the land wires we are to a large extent helpless. It would be interesting to know whether anything is being done to strengthen our position in the latter respect. A scheme has long been under the consideration of the Government for an entirely independent line to our Eastern possessions—one which would altogether avoid foreign territory. Has any decision been come to regarding it? The proposal is one that must be grappled with, not during the troublous excitement of war but in the calmer days of peace. It may be that the Paris Conference will have the effect of once more directing attention to a subject which this country of all others cannot afford to see neglected."

The Australian Cables.—A Melbourne telegram states that the Victorian Government has consented to allow those Colonies which do not contribute to the Cable Subsidy the benefit of the proposed reduction of the tariff for press telegrams between England and Australia. It declines, however, to extend the subsidy to 20 years.

Repairing a Telegraph Cable.—The cable steamer *Lady Carmichael* has completed the repairs of the French cable between Brest and Land's End, and communication has been restored.

Incandescent Lamp Patents.—In this issue of the REVIEW the evidence of Sir Frederick Bramwell for the plaintiff Edison-Swan Company is given at great length, and will doubtless form the chief attraction in our columns. The judgment having been delivered, we shall be pleased to insert expressions of opinion on the merits of the case.

Earth Currents.—The effect noticed by one of our correspondents when recently testing telephone lines, and which he attributes to so-called earth currents, was probably due to the galvanic couple formed by the coal dust at the pole in question, and the distant earth plates on each of the wires. These earth *plate* currents are by no means unusual.

Galvanometer Problem. — A "Puzzled Student" writes:—"Amongst the questions asked in a recent examination held in London for students of electrical science, the following was one:—(4) Two tangent galvanometers whose coil frames are of exactly the same dimensions, and whose general make is the same, are joined up in series, and a current passed through them. The deflections observed are 45° and 30° respectively. What are the relative resistances of their coils? Some solution of this problem giving the required resistances will greatly assist.

The following is the solution of the problem:—If two galvanometer frames of exactly the same dimensions are wound to different resistances, R_1 and R_2, their deflective effects, d_1 and d_2, for the same current will be such that

$$d_1 : d_2 :: \sqrt{R_1} : \sqrt{R_2}$$

(see Kempe's "Handbook of Electrical Testing," page 414, second paragraph).

But since the galvanometers are of the tangential form, we have

$$d_1 : d_2 :: \tan. 45° : \tan. 30°,$$

therefore

$$\tan. 45° : \tan. 30° :: \sqrt{R_1} : \sqrt{R_2},$$

or

$$1 : \sqrt{3} :: \sqrt{R_1} : \sqrt{R_2}$$

that is

$$R_1 : R_2 :: 3 : 9.$$

The West London School of Telegraphy.—We have received a recently issued and well got up prospectus of this school, which, under the energetic management of Mr. W. Lynd, the principal, is making great progress. A submarine branch has recently been added and all the necessary instruments for instruction, including an artificial cable manufactured in the workshop of the school, have been installed.

A Safeguard against Fire.—At the last meeting of the Balloon Society held at the Royal Aquarium, Westminster, a paper on "Electricity as a safeguard against Fire," was read by Mr. Alfred Thompson, of the firm of Thompson and Ritchie. This was the third paper read in connection with the Fireman's Exhibition, and Mr. W. H. Le Fevre, the president, stated that Messrs. Thompson and Ritchie had received the gold medal from the committee.

Electric Locomotion.—The *Daily News* in commenting upon the Liverpool Exhibition says:—"We need now a Watt and a Stephenson to take up and perfect the means of applying to navigation, to travel, and to manufactures, the power of electricity." Our daily contemporary has not quite grasped the situation; the Watts and Stephensons of electrical science have long since passed away. Faraday, Jacobi, and Davidson, have shown the applicability of electricity to locomotion; the present generation tries only to make a *commercial* success.

Scientific Recreations.—We shall hope to publish in our next a very charming illustration of the transformation of physical forces in which electricity plays the principal part.

The Dynamicables.—The club room of this society in the Victoria Mansions Restaurant is now open for the use of members from 10 a.m. till the closing of the restaurant at 12.30 a.m. on week-days, and on Sundays after 1 p.m. Weekly and other papers connected with the objects of the society are provided.

The Navigation of the Suez Canal.—We understand that Mr. Fred. Walker, late engineer to the Electric Locomotive and Power Company, left England on Wednesday last for Egypt for the purpose of carrying out the navigation of the Suez Canal by the electric light.

Magnetising Watches.—Mr. E. Hancock, M.E., of Cardiff, in reply to a note which appeared in the REVIEW on the 7th inst., says:—Magnetic appliances such as a belt or chest protector provided they are properly charged, will impart sufficient magnetism to a watch to affect its working; I have frequently had complaints. One gentleman had three watches stopped by wearing a chest-protector, and in order to weaken the effect he put the protector on his back.* I regret however to say there are appliances sold and called magnetic that would not affect a watch if it was folded up in the appliance; such applicances would of course be useless to the wearer.

Electric Locomotion in New York.—The governor has approved the Broadway Arcade Railway Bill, which provides for the construction of an underground railway throughout Broadway driven by electricity, 3 per cent. of the earnings being paid to the city. The work will begin soon, ample capital having been subscribed for the project.

Magnetic Effects.—The results given by Professor Carhart of some experiments made by him, and which appear in our columns to-day, are very instructive, and should prove exceedingly useful to those who may have obtained similar puzzling and contradictory effects.

An Opportunity.—The Corporation of South Shields invite tenders for the working of the tramways, under lease. The total length of the tramways is 2½ miles, passing through many of the principal streets of the town, and extend from the Pier to Hudson Street, at Tyne Dock. The permanent way and rails are maintained in a state of efficiency by the corporation, and are suitable for the use of horse-power. Very excellent and efficient stabling will be included in the lease. Specifications, with form of tender, may be obtained, and plans, showing the route of the tramways, inspected on application to Mr. M. Hall, borough surveyor, Chapter Row. Is not this a good opportunity for someone with enterprise to show what can be done with electricity as a motive power?

Colonial and Indian Exhibition.—The Reception Committee, recently formed by direction of His Royal Highness the Prince of Wales, Executive President of the Royal Commission, is desirous of offering a fitting and cordial reception to Colonial and Indian visitors of distinction during their visit to England, by facilitating, so far as may be possible, their arrangements for visiting places of special interest in the United Kingdom. To enable the committee to do this, funds are required; and those who may be desirous of co-operating are invited to subscribe to the object in view. Subscriptions can be sent to the London and Westminster Bank, West End Branch, St. James' Square, S.W., or to Mr. Arthur Hodgson, C.M.G., general secretary, at the office of the Reception Committee, "Old London," Exhibition Buildings, South Kensington, or to Mr. H. Trueman Wood, the treasurer, Society of Arts, John Street, Adelphi. Cheques should be crossed "London and Westminster Bank," West End Branch.

* We should like to know what the wearing of a chest protector on the back produced, not in the watch, but in the man. —EDS. ELEC. REV.

The Cost of Electric Lighting.—*Gas and Water* in its last issue is rather hard upon the electric light. It quotes Greenock as being the place in which, from the cheapness of motive power, electric lighting ought to have been a pronounced success; yet even here, says our contemporary, electricity has been a failure. Quite recently a committee of the corporation was asked to report upon the best means for lighting a new dock. In the report which has been presented, it stated that the cost of an engine, dynamo, cable, and incandescent lamps for electricity would be nearly double that to which gas fittings would amount, and the committee, therefore, agreed that the lighting should be by gas. This decision has been confirmed by the corporation, because the machinery necessary for an installation would cost £786, with £150 a year to keep it in order, while the total outlay for gas was estimated at £200 a year.

A Simple Ampèremeter.—Mr. Frederick Drexler, electrical engineer to the firm of B. Egger & Co., of Vienna, writes to us thus:—"Having only now read the number of August 15th, 1885, of your valuable paper I found an article under the above heading, describing the measuring instruments of the Vienna Town Hall installation. Allow me to communicate to you that these instruments are of my invention, my name being visible on every instrument manufactured by B. Egger & Co., in Vienna. Figure 1 of the said article represents a voltmeter and not an ammeter as said in the description."

Cable Rupture in Deep Water.—The duplicate Jamaica-Porto Rico cable again became interrupted on November 28th last. The ss. *Grappler*, belonging to the West India and Panama Company, when on her way to repair the Cuba-Jamaica section was ordered to examine the locality of this interruption. The break was found to be in about 2,400 fathoms of water.

The Working of Tramways.—Mr. Reckenzaun's contribution, which will be found on p. 464 of our present issue, is of considerable importance. We wonder when the promoters of new tramways, like that for instance to be constructed by the Weston-super-Mare, Clevedon, and Portishead Company, will give electrical locomotion a trial? The line for the company above-mentioned appears admirably adapted for this method of traction, if one may judge from the description given in the prospectus. The admirable papers on electric locomotion which Mr. Reckenzaun has written for the REVIEW ought to be attentively perused by everybody interested in the development and economical working of tramlines. Nothing approaching these articles has ever before been published, and as Mr. Reckenzaun is admittedly the greatest authority on the subject, they possess a value which can scarcely be over-estimated.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Woodhouse and Rawson Electric Supply Company of Great Britain, Limited.—An agreement dated 14th inst., and filed on the 15th inst., provides for the allotment of 2,000 fully paid-up shares of £10 each as part of the consideration for the purchase of the business of the supply department of Messrs. Woodhouse and Rawson.

Woodhouse and Rawson Electric Contract and Maintenance Company, Limited.—The transfer to this company of the business of the contract departments of the Messrs. Woodhouse and Rawson and of the Crossley Telephone Company, Limited, so far as they relate to Lancashire, Yorkshire and Cheshire, is regulated by an agreement made between Otway Edward Woodhouse and F. L. Rawson of the first part, the Crossley Telephone Company, Limited, of the second part, and the Company of the third part. Part of the consideration for the respective sales will be £5,000 in fully paid shares. Messrs. Woodhouse and Rawson and the Telephone Company each agree to subscribe for 250 shares of £10 each and to pay £1 per share on allotment and the balance as required by the Company.

Anglo-American Brush Electric Light Corporation, Limited.—The annual return of this company, made up to the 24th February, was filed on the 12th inst. The nominal capital is £400,000 in £5 shares. The total number of shares taken up is 46,982, and of these 23,979 are fully paid and 23,003 are paid up to the extent of £3 per share, the calls paid amounting to £188,904; 102 forfeited shares have been re-issued as £5 shares with £3 paid up. As compared with last year's return, the paid-up capital shows an increase of £31,410.

Railway and Electric Appliances Company, Limited.—An extraordinary general meeting of this company was held on the 28th ult., when it was resolved that the following be added to the articles of association: "Article 38A. The directors may accept from any member, on such terms and conditions as shall be agreed, a surrender of his shares or stock or any part thereof." This resolution was confirmed at a meeting held on the 13th inst., and was duly registered on the 14th inst.

Oriental Telephone Company, Limited.—The annual return of this company, made up to the 4th inst., was filed on the 11th inst. The nominal capital is £300,000 in £1 shares. 298,242 shares have been taken up, upon 220,000 shares 11s. per share has been called, and 78,242 are considered as paid up. The calls paid amount to £120,883 6s. 3d., and £116 13s. 9d. remains unpaid.

British and Colonial Dermatine Company, Limited.—An agreement dated 7th inst. relates to the purchase by this company of the goodwill, premises, assets, and stock-in-trade of the Dermatine Syndicate, Limited, including the following letters patent granted to Maximilian Zingler, viz.:—No. 1,153, dated 9th March, 1882, for an "Improved substitute for gutta percha for insulating, waterproofing, and other purposes;" No. 242, dated 15th January, 1883, for "Materials for the production of substitutes for gutta percha and India rubber;" No. 3171, dated 12th February, 1884, for "Improvements in the manufacture of substitutes for leather." The purchase consideration is £40,000 in cash or one moiety in cash and the other in fully paid shares, at the discretion of the directors.

Brilliant Incandescent Lamp Company, Limited. An agreement dated 21st ult. and filed on the 13th inst., provides for the purchase of the interest of Messrs. G. Zanni and Rowland Matthews in a secret process for the manufacture of filaments for incandescent lamps for electric and other lighting. The purchase consideration is £1,670, payable £1,200 in fully paid shares and £470 by mortgage debenture bonds bearing 5 per cent per annum interest. Registered office, 12, Ironmonger Row, St. Lukes.

Alfred Slatter & Co., Limited.—The registered office of this company is at 11, Sekforde Street, Clerkenwell.

Westminster Joint Stock Syndicate, Limited (Cable Manufacturers).—The registered office of this company is at 63, Queen Victoria Street, E.C.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 14th were £2,230, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 15th May are £2,774, as compared with £3,780 in the corresponding period of 1885.

NEW PATENTS—1886.

6102. "Electrical switching apparatus." W. T. GOOLDEN, A. P. TROTTER. Dated May 5.

6107. "Telegraphic or telephonic transmitter." A. BROWNE. (Communicated by D. Piedrahita.) Dated May 5.

6114. "Chromic acid batteries." D. G. FITZGERALD. Dated May 5.

6139. "Periodically adjustable switches." H. HART. Dated May 6.

6145. "Preparing aluminium by electrolysis." A. C. HENDERSON. (Communicated by L. T. Heroult.) Dated May 6.

6167. "Making filaments for incandescent electric lamps." O. R. SWETE, W. C. MAIN. Dated May 6. (*Complete.*)

6201. "Magneto machines." T. BENNETT. Dated May 7.

6203. "Preparation of carbon filaments for electric lamps." H. J. HADDAN. (Communicated by C. Sell.) Dated May 7.

6206. "Electric alarm or check for use in connection with railway signals." J. RICE. Dated May 7.

6220. "Electrical resistance switches." M. H. SMITH. Dated May 7.

6224. "Lightning arresters for telephonic exchanges and telegraph offices." P. GANNON. Dated May 8.

6233. "Showing electrical phenomenon." A. PHILBURN. Dated May 8.

6235. "Reversible electric machines." J. ENRIGHT. Dated May 8.

6245. "Electric machines." C. WELLS. Dated May 8.

6246. "Incandescent lamps." C. WELLS. Dated May 8.

6247. "Adapting incandescent lamps to the requirements of illuminations and pyrotechnic displays." C. WELLS. Dated May 8.

6287. "Electric secondary or storage batteries." W. TAYLOR. Dated May 10.

6303. "Electrical indicators." B. J. B. MILLS. (Communicated by J. W. Howell.) Dated May 10.

6322. "Operating sewing machines and driving other machinery by electricity." J. H. JOHNSON. (Communicated by E. Recordon & Co.) Dated May 11.

6345. "Localising faults in submarine telegraph cables." J. GOTT, H. KINGSFORD. Dated May 11. (*Complete.*)

6357. "Control and regulation of charging and distributing circuits where secondary batteries are used." Sir D. L. SALOMONS. Dated May 11.

6369. "Measuring electricity." S. PITT. (Communicated by J. Cauderay.) Dated May 11.

6416. "Induction coils for telephonic purposes." H. H. LAKE. (Communicated by E. B. Hamlin.) Dated May 12.

6422. "Armatures for magnets or dynamo-electric generators or motors." J. G. STATTER, S. L. BRUNTON. Dated May 12.

6466. "Telephones." H. W. B. BRIGHTEN. Dated May 13.

6471. "Electric telephone." J. G. LORRAIN. Dated May 13.

6487. "Simple and compound switches for electrical currents." W. HARTNELL. Dated May 14.

6507. "Appliances for use in electric lighting." R. P. SELLON. Dated May 14.

6508. "Electric meters." R. P. SELLON. Dated May 14.

6534. "Electric arc lamps." C. A. A. CAPITO. Dated May 15.

6574. "Electric burglar and fire alarm apparatus." S. TAUSSIG. Dated May 15.

6586. "Apparatus for lighting railway trains by electricity." T. P. CARSWELL. Dated May 17.

6596. "Double solenoid indicating movement for electrical indicators." C. W. Cox. Dated May 17.

6598. "Electrical switches and apparatus." R. H. C. NEVILE. Dated May 17.

6599. "Constructing, fixing, and fitting electrical insulators for telegraphs." J. E. GRIFFITH. Dated May 17. (*Complete.*)

6604. "Galvanic cell for bell-ringing and other purposes." G. H. BAYS. Dated May 17.

6619. "Electro-type printing instruments." O. ROMANZE. Dated 17.

6621. "Indicators for electric bells." C. W. STEWART. Dated May 17.

6646. "Apparatus for closing electric currents." J. ENRIGHT. Dated May 18.

6669. "Electric valves." W. S. JOHNSON. Dated May 18. (*Complete.*)

6678. "Electric bell and house telephone apparatus and systems and telephonic appliances." C. HERZ. Dated May 18.

6690. "Boring to great depths for water, coal or other minerals, by aid of electricity; applicable also to tunnel, drift, &c., boring." R. RICHARDS, H. R. LANDON. Dated May 18.

6697. "Dynamo-electric machines." N. GLOUCHOFF. Dated May 18

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1885.

5314. "Improvements in the regulation of electrical circuits, and in apparatus relating thereto." D. L. SALOMONS. Dated April 29. 8d. Relates to the regulation of electrical currents, by which tramcars or other moving traction engines or rotary or other motors are driven, or upon, or in connection with which, electrical lamps are situate, and is designed to render constant, or to regulate within small limits or known limits, the electromotive force of the said currents, so as to prevent injurious action upon the current generators, from the sudden cutting out of one or more of the said tram-cars, or other motors, or other machinery or lamps. The device by which the inventor produces this desired effect, is similar to that described in Letters Patent dated January 27th, 1885 and numbered 1184, consisting of either a regulator-motor, running at constant speed in a "parallel arc," or a regulator-dynamo "in parallel" running at constant speed, both developing electromotive force counter to that of the main circuit, and thus affording automatic regulation of the electromotive force in the said circuit, as more fully described in the aforesaid application.

5494. "Improvements in dynamo machines and electro motors." C. A. A. CAPITO and M. P. HARDT. Dated May 4. 8d. The inventors construct the armature of a number of soft iron grid discs with intervening soft iron washers, the whole being mounted on a shaft which by preference is made square to ensure accurate correspondence of the circumferential parts of the grid discs. These latter are formed with a number of narrow or light radial spokes or arms proceeding from the central boss or nave and terminating in a narrow ring which on its outer circumference is provided with a number of short radially projecting bars the sides of which however are so formed as to produce parallel spaces in which the wire is to be coiled.

5551. "Improvements in electric arc lamps and in the mode of regulating the same." M. H. HURRELL. Dated May 5. 8d. Relates to certain improvements in electric arc lamps by which they are rendered suitable for use with electric generators giving a current of approximately constant potential, and more particularly to a new method of regulating such lamps. The invention also relates to certain details of construction for ensuring delicacy of action of the regulating mechanism, for compensating the differences in the weight of the moving parts produced by the consumption of the carbons, and for adjusting the position of the carbon of the lower carbon holder.

5679. "Improvements in portable electric lamps." J. C. MERRYWEATHER and C. J. W. JAKEMAN. Dated May 8. 8d. Consists of a battery, preferably of carbon and zinc, excited by a solution of bichromate of potash and sulphuric acid, contained in a divided trough of ebonite or other suitable material. In one form of lamp, apparatus is provided for withdrawing the elements from the liquid when the light is not required, and a commutator or switch is arranged to connect a portion of the elements to the lamp when the battery is first charged and a further number as the liquid becomes decomposed. The electric light is on the incandescent system, and the whole is contained in a case or lantern preferably of metal fitted with a suitable glass and reflectors.

5990. "Improvements in the manufacture of telegraph poles, columns, pillars, flagstaffs, signal posts for railways, lamp posts, fence posts, and other posts; rolls for engineering and other purposes, chimneys for factories, pipes for conveying liquids or gases, and other like tubular articles; railway and tramway sleepers, doorsteps, lintels, window sills, building blocks; and tanks, casks, and drums for containing liquid, semi-liquid, and solid matters." D. WILSON. Dated May 15. 1s. 1d. Consists of a tube formed of a core of metal coated both externally and internally with concrete.

6037. "Improvements in electro-motors and dynamo machines." M. IMMISCH. Dated May 16. 8d. Relates to improvements in electro-motors and dynamo machines where two field magnet poles and two brushes are employed, with three armature coils wound on an iron core, such coils being either single coils proper, or they may be subdivided into a greater number which shall always be the product of three and any even number, for instance, there may be 3, 6, 12, 24 and so on. The commutator is divided into a number of segments, altogether of double the number of coils used, which segments are divided into two series bridged over by the brushes, that is to say, each brush shall rest on both series at the same time. The commutator segments are equally divided between the two series, and have an angular displacement with regard to each other such that the line of division between two adjacent segments in one series shall be opposite the middle of a segment belonging to the other series.

6325. "Improvements in dynamo-electric machines." T. PARKER. Dated May 23. 11d. A pair of magnets is fixed on opposite sides of the centre of the machine, and the four poles of these magnets are arranged at, preferably, equal intervals around the armature, and so as to alternate as to polarity. In order to maintain the poles in their proper position in relation to the armature, the two poles of one magnet are distanced apart with suitable non-magnetic distance pieces, and the north pole of each magnet is held to the south pole of the opposite magnet, respectively, by means of suitable non-magnetic distance pieces; and, if the pairs of magnets are arranged so that their axis is horizontal, or

approximately so, the lower pole of each magnet is carried from the bed of the machine upon suitable non-magnetic blocks. Whether the axis of the magnets is horizontal or vertical the yoke of each pair may be carried by the framing of the machine, or the magnets may themselves form the frame of the machine. The coils are wound in two divisions each, such divisions being at right angles, or approximately so, to one another on the surface of the iron core of a drum armature. One division of the second coil is laid on immediately within one of the divisions of the first coil, and the other division of the second coil is laid on at a distance of, approximately, 90° from the first division of such coil, and so on around the armature, the winding being continued for successive revolutions around the armature until the whole surface of the armature is covered with coils. These coils are connected so that the ending of one is brought to a commutator strip with the beginning of the next coil, and so on until the whole of the coils are connected into one continuous conductor.

7143. "An improvement in 'Morse inker' apparatus for telegraphic and other purposes." C. D. ABEL. (Communicated from abroad by the firm of Siemens and Halske, of Berlin.) Dated June 11. 8d. Consists in arranging the writing disc or "inker" in such a position that a tangent to that point of its periphery which is in contact with the paper strip lies at right angles, or nearly so, to the direction of motion of the latter, and consequently of the direction of the writing produced.

7312. "Improvements in electro-dynamic motors, and in methods of and apparatus for regulating the same when used stationary or on electric railways." T. J. HANDFORD. (Communicated from abroad by F. J. Sprague, of New York.) Dated June 16. 11d. Relates chiefly to a method of operation or regulation of a shunt wound electro-dynamic motor or a circuit of constant difference of potential, which may be a circuit of a system of electric lighting or an electric railway system. This method consists in first introducing the motor into circuit with a very strong field and with a small difference of potential at the terminals of the armature circuit so that the motor starts slowly; then progressively raising the armature circuit potential until that circuit is brought up to full potential, and then, to still further increase the speed, weakening the field magnet strength; after this during the operation of the motor, its speed and power are diminished or increased by strengthening or weakening the field magnet.

8331. "An improved carbon element for galvanic batteries." A. M. CLARK. (Communicated from abroad by C. R. Goodwin, of Paris.) Dated July 9. 8d. Consists in embedding a screw threaded metal rod in the carbon composition at the time of moulding, and before burning the element a part of the screw rod remaining projecting from the element and receiving a binding nut or equivalent means of making contact with the conducting wire or wires.

11175.* "Improvements in the arc striking mechanism of electric arc lamps." C. F. COOKE and T. ROBINSON. Dated September 19. 8d. The inventors use a solenoid, the coil of which is of coarse wire and carries all or nearly all the current. The soft iron core of the solenoid is connected by the rod with a lever pivotted to the framework of the lamp, while a little within the pivots of this lever the lever itself carries, by means of pivots carried thereby, a spindle on which are mounted a pinion and a ratchet wheel, the two together not being able to rotate in one direction without driving round a spur wheel which is mounted on the same spindle. The rack or carbon carrier has teeth cut in that side which comes against the before-mentioned pinion, the rack and pinion being thus in gear. The before-mentioned spur wheel gears into a second pinon upon the axis carrying the second wheel of a train of wheels, the second axis being mounted on bearings carried by the fixed framework of the lamp.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

AN ordinary general meeting of this Society, was held on Thursday, May 13th, Professor HUGHES, F.R.S., President, in the chair. The minutes of the last ordinary general meeting having been read and confirmed, and the list of new and proposed new members announced, a paper on "Long Distance Telephony" was read by Mr. W. H. PREECE, F.R.S.

In commencing his paper the author stated that he had some difficulty in choosing a title for his subject. The one selected would give the idea that the question of telephoning to extreme distances was alone to be spoken of. There were two ideas to be considered. 1st. What was the extreme distance to which speech of any kind could be transmitted? and 2nd. To what distance could speech sufficiently good for commercial purposes be transmitted? The latter was that with which he proposed to deal. As regards "Trunk" wire working, this he would state was called in America "extra-territorial" working. Another phrase in use in America was "toll line" working, used to express a system of working by toll payments, and not by subscription. On the Continent, in Belgium, the two systems were defined as "local" and "inter-urban" working; the latter term was a very good one. The main question to be considered was how far recent improvements had rendered such working practicable. The improvements in telephone instruments within the last few years have been very small indeed. Practically no improvement on the original Bell receiver, brought over by the author from America in 1877, had been effected; and scarcely any improvement on the original microphone transmitter had been made. All so-called improvements in telephony had been really only new tunes played on old strings, the inventions of Bell, Edison, and Hughes, being the three strings. All practical transmitters have been based on the discovery of Hughes, and not that of Edison. Of the many inventions which had been brought out, and which were to do wonders, almost all had come to nothing.

A comparison between the progress made in America and this country was remarkable. In America in 1877 there were no exchanges, and only 780 telephones in use. In 1880 there were 100 exchanges, and 60,800 instruments; in 1883 249,700 instruments; in 1885 325,574 instruments, and 782 exchanges. In Canada, with a population of about 3,000,000, there were 18,000 telephones; whilst in England there were only 13,000. In fact there were more telephones in use in New York and Brooklyn than in the whole of the United Kingdom. In Chicago there are 3,630; in Philadelphia, 2,310; and in Cincinnati, 2,535 telephones. Coming now to Europe we had the following numbers:—

Berlin - - -	4,248	Rome - - -	2,054
London - -	4,193	Manchester - -	1,171
Paris - - -	4,054	Liverpool - -	1,169
Stockholm - -	3,825	Glasgow - -	1,041

For some reason or other telephonic development in England has been very slow. It was not a question of charges as the latter are lighter in this country than in America, and, moreover, the restrictions are not so great. As regards the speaking distance of telephones, in 1877 he had spoken through the submarine cable between Dartmouth and Guernsey, a distance of 60 miles; the speech was perfectly clear though not loud. Talking had also been carried on between Dublin and Holyhead, a distance of 60 miles. Subsequently experiments were made on Muirhead's artificial cables, the result being that it was found impossible to speak to a greater distance than 20 miles on a cable of the dimensions of the Atlantic type. Lord Rayleigh, in a paper read before the British Association at Montreal, had arrived at a similar conclusion by a mathematical deduction. In Persia speech had been transmitted through an aerial wire between Tabris and Tiflis, a distance of 390 miles. In India experiments had been successful through 500 miles, and in America through 1,000 miles. Mr. Van Rysselberghe would detail his experience of long distance working in America. The question of long distance telephony was not one of instruments, it was one of line wire purely, and the effects of induction, resistance, mutual induction, earth currents, swaying of wires, and atmospheric agencies, had to be considered. The result of all these was to blur or muffle the speech. That this could take place over a short circuit was proved by the fact that on a wire between Gloucester Road, Regent's Park, and the General Post Office, a distance of four miles only, telephonic communication could never be carried on with any form of apparatus yet brought out. It was quite easy to eliminate the effects of external disturbances by the use of a twisted metallic loop, as was done on all the Post Office telephone circuits. In 1879 double underground wires, constructed by W. T. Henley, were laid down in the Newcastle district; over these wires speech was possible to a distance of eight miles only. Later on gutta-percha insulated wires were laid down, and then the distance was increased to 12 miles. Since 1885 four-wire cables of the ordinary underground wire size have been used, and although through this wire 20 miles was the practical limit of distance, yet speech could be carried on through a distance of 40 miles, though the sounds were weak. In order to determine the distance through which communication could be carried on through overhead lines, four iron wires were erected on the twist principle between London and Manchester, through Liverpool. The wires were of No. 8 gauge, and had a resistance per mile of 12 ohms. It was found that speech could not be carried on through these wires to a greater distance than 100 miles. Talking through 150 miles was possible, but not satisfactory. Through 170 miles communication could just be carried on, and through 200 miles only muffled sounds could be heard. If copper instead of iron wire had been erected the results would have been very much better; in fact, communication with Manchester would have been quite practicable. In America there were for telephonic circuits 31,398 miles of poles and 42,461 miles of wire. Single wires on single poles were used for trunks. The charge on the toll system was 25 cents (one shilling) for five minutes' conversation. The total earnings on all the trunks was $538,740 per year, or $12·6 per mile of wire. Talking over 95 miles was not good. On a 65 mile line of copper the results were much better. Between New York and Boston, a distance of 350 miles, speech was very good on two copper wires; the great difficulty was to keep the wires in good order. The toll system was usually started by getting a number of toll tickets subscribed for, when this was done the lines were put up. This plan was found to be most successful. The trunk system was not altogether a commercial success, as the number of inter-communications did not, as a rule, exceed 30 per day. The existence of the trunk

* This specification was accidentally inserted last week in an incomplete condition.—EDS. ELEC. REV.

system, however, attracted people to local exchanges. In England the trunk wires were more used; the United Telephone Company have, however, only one trunk in use, viz., that between London and Brighton. The Lancashire and Cheshire Company have a network of trunks; these latter are double copper lines, but, for some reason or other, only one of the two wires is used; the working in consequence was not so good as it might be, except in the evening, when satisfactory results had been obtained over a length of 60 miles. The National Telephone Company were also enterprising, and had established a good business in Scotland. The most complete system of trunks that existed was in Belgium, where the Government had the control of the whole system on the Van Rysselberghe system. In this system the effects of induction were prevented by making the rise and fall of the primary currents to be gradual instead of sudden. The inventor obtained the idea of his method by observing that the currents going out from Brussels produced a strong effect on the telephone, whilst the currents received from London produced scarcely any effect at all. Every telegraph wire is now armed with apparatus on the Rysselberghe system, and many telephone circuits are worked on the telegraph wires. All the busy centres are so connected. The charge was one franc for five minutes' conversation. The circuits were fairly well used. In Belgium, it should be remarked, the circuits are all short. It might be asked why the system could not be introduced in England; one reason was that the introduction of the retarding magnets, &c., would seriously diminish the speed of working of the Wheatstone instruments. At the present time the latter were worked at a speed of 300 words a minute, and were capable, if required, of working up to 400 words; but the intercalation of the Rysselberghe magnets decreased the speed to 150. Moreover, the general introduction of the system would involve the use of numerous pieces of extra apparatus.

In Belgium the number of circuits running into Brussels is 133, in London there are 940, in Manchester 202, Liverpool 168, Glasgow 154, besides which there are a very large number of railway circuits, all of which would have to be armed with the retarding apparatus if the system were to be carried out. The capital required for all this would be very great, and it would be cheaper and better to erect special trunk wires. The system had been adopted in France and answered well. In no country had the telephone system been so completely developed and systematically arranged as at Newcastle. The excellent way in which the work had been planned was due to Mr. A. W. Heaviside, the superintendent of the district. Double wires were in use everywhere, and the telephone instruments were joined to the wires in parallel. By this arrangement, and having the call indicators of rather large dimensions, the telephonic currents could not pass through these indicators owing to their magnetic inertia, but would only pass through the telephone whose indicator was cut out of circuit. This arrangement, which was known as the bridge system, answered admirably. In spite of the oft repeated statement that the Post Office stifles invention, he would affirm that the only improvements which had been made in telephone working had been made by the Postal Telegraph Engineers. He was of opinion that when the telephone patents expired there would be a great development in telephony.

In the discussion which followed the reading of the paper,

Mr. VAN RYSSELBERGHE said that he would be prepared at some future date to fully explain his system to the Society by means of the apparatus which he had devised. He would also prove that the first person to transmit two simultaneous messages on one wire, and also the inventor of the first speaking telephone. was Mr. C. F. Varley; one of his inventions works as well as does the Bell telephone. With reference to the question of line wires he had found it impossible to transmit speech properly over an iron wire to a greater distance than 150 miles. The difficulty was not want of volume but want of distinctness. With copper wire very different results were obtained. A wire of iron 3 millimètres in diameter, and covered with copper of 1½ millimètres in thickness, also gave much better results; talking in this case was good over 300 miles, and possible over 500 miles. With a No. 12 copper wire speech was very good over 700 miles, and with a large compound iron and copper wire talking was good over 1,010 miles. The electro-static capacity of this wire was 27 microfarads. The results with this wire were most remarkable, the articulation being so loud and clear that it was not necessary to keep the telephone receiver close to the ear. The general opinion was that speech could have been transmitted through 3,000 miles of line. With the copper wire of No. 12 gauge, although the speech was weak through 500 miles, it was not muffled. He agreed with Mr. Preece that the conditions of telephone working are different in England to what they are elsewhere, but he hoped that Mr. Preece would agree that if long distance telephony became practical elsewhere England would not remain behind hand. He hoped to have telephonic communication shortly established between Paris, Brussels, Amersterdam, and Rotterdam. He thought that if copper wire of proper dimensions were used that a practical and commercial success would be attained. In America a technical difficulty existed with reference to long distance telephony as the agreements prevented the New York and Chicago line being used. The system of intercommunication in Belgium paid well.

Prof. SILVANUS THOMPSON differed with Mr. Preece as to what was required for long distance telephony; he considered that instruments had a great deal to do with the question, the receivers were, he thought, too sensitive and the transmitters not powerful enough. The London and Globe Company, who had used the Hunnings transmitter and an insensitive receiver, had very much better speaking on their lines than the United Company had. The resistance of the line wires ought to be high by the employment of copper wires of small diameter. Speaking of transmitters, he had found that if a microphone was formed of copper and selenium mixed, the distinctness of the articulation was excellent though the volume was rather small; such transmitters, however, did not stand the damp well. With reference to Mr. Preece's statement as to the work done by the Government officials, he would ask whether the Hunnings transmitter, the Hughes microphone, were Post Office inventions? Mr. Van Rysselberghe, he would point out, had only carried the original invention of Dr. Roseburgh and Dr. Black, in 1878, a stage further, but the latter was an important stage. The two gentlemen he had mentioned had first pointed out that the effect of an electro-magnet could be nullified by means of a condenser.

Mr. BLAKESLEY disagreed with Prof. Thompson as to the question of resistance in telephone line wires. In the case of an overhead wire of 5 ohms resistance per kilometer, at a distance of 80 kilometers the effect of a high note would lose one-sixth of its value; this accounts for the fact that the lowest tones will go furthest. He did not agree that self-induction is the cause why copper wire works better than iron. In some respects, indeed, self-induction is an actual advantage. He thought the question of capacity had not been sufficiently taken account of.

Mr. PREECE in replying, pointed out that as regards Prof. Thompson's remarks, the New York-Chicago experiment had conclusively proved that the line was the important element in long distance working. He had not stated that all improvements in telephones had been made by the Post Office agency, but that all improvements in telephone *working* had been effected by them, which was a very different thing. He contradicted the statement that it had been legally declared that the telephone was a telegraph; it had only been held that messages sent by telephone were telegraph messages. As regards the impression that prevailed as to the Post Office having the power to use telephone instruments to any extent they liked, he would point out that this was not the fact; but the Post Office some time ago had got possession of 20,000 telephones, which were being gradually used up.

The meeting then adjourned.

Mr. A. BERNSTEIN has forwarded to us the following remarks in reply to the criticisms on his recent paper on "Electric Lighting by Means of Low Resistance Glow Lamps" * read before the Society of Telegraph-Engineers and Electricians:—

Mr. President and Gentlemen,—I desire, first of all, to express my thanks for the kindness with which you have received my paper, and my pleasure in finding that it has been the occasion of such an interesting discussion. If I am more grateful to one more than to another for having taken part in this discussion it will appear natural that I should be so to Mr. Swan, whose name is so intimately connected with the history of incandescent lamps. As I never had the pleasure of meeting Mr. Swan before, I gladly avail myself of this opportunity to express my admiration and personal regard for the perseverance and skill which Mr. Swan has displayed in overcoming all those difficulties, which the incandescent lamp must have offered in its early stages of manufacture.

In my reply to your remarks I shall follow out the same course I pursued in my paper, and again speak first of the lamp itself and then of the system of lighting.

Objection has been raised against the use of the word "strain" as indicating the relation between candle-power and number of watts required, and it has been mentioned that the word "efficiency" is already in use for this purpose.

Although I am well aware that such is the case, I do not think that the application of this word is an appropriate one. Efficiency of any apparatus is generally considered as a term specifying an inherent quality of the apparatus; for instance, in a dynamo the relation between external and internal work. But the number of watts per candle-power in an incandescent lamp is an entirely arbitrary matter, not connected in any way with the construction of the lamp—as is, for instance, the case in an arc lamp—and merely affecting its life.

If we could combine the life, the light and the power into one expression the word efficiency might be well applied to it, but as commonly used, the word is entirely misleading; a lamp having a so-called high efficiency, according to the test of some authority, may in reality be a lamp of very inferior qualities.

In making comparative tests between glow lamps, we have to note their behaviour and their length of life when submitted to the same strain; in this respect the Committee of the Franklin Institute, to which we are much indebted for its meritorious work, seems to have made a mistake. The word strain may not be the best which can be found for the purpose, and I hope somebody will propose a better one. While I am speaking of measurements I may be allowed to add a few words in regard to the question which has of late been much discussed, viz., the selection of a standard of light.

You will remember that in my paper I have described a lamp in which the expansion of the carbons when raised to a high temperature was indicated by the motion of a lever. If you consider that the light radiated by the carbon only depends on the surface and the temperature, then you will easily perceive that the lamp shown in fig. 1 of my paper seems well suited for a standard. The indications of this lamp can always be reproduced under the same

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* See ELECTRICAL REVIEW for April 2nd, 1886.

conditions, and they are free from circumstances which are not easily controlled. I do not think this lamp should be used as a commercial standard, for which purpose suitable glow lamps of ordinary construction might answer, but the standard which I hereby propose may be used as a normal with which the commercial standards are to be compared from time to time.

Mr. Rawson has remarked that the deterioration of the carbons of which I have spoken, appears to be only due to the imperfect vacuum in the lamps, on which I have made my observations. I should say that just the contrary is more likely to be the case. If the vacuum is a very high one, such as Prof. Crookes used in his famous experiments, then the action of throwing off carbon from the negative side, and, therefore, the gradual deterioration of the high resistance lamp takes place. In fact, it might appear questionable whether it would not be advisable to produce such a state of atmosphere inside such lamps by the introduction of an inert gas that the lamp can no longer be considered as a Geissler tube; if, on the other hand, the economy of the lamp would not be greatly decreased by these means. I must further differ with Dr. Fleming, who wants us to believe that the deterioration is merely the effect of heat. The very interesting observations which Dr. Fleming himself published some time ago contradict his statement. If only destruction produced by heat takes place, then the disintegration ought to extend in an even manner over the whole carbon, and the deposit should be evenly distributed over the inside of the bulb. We all know that this is not the case, and it seems to me that the explanation which I have given in my paper, considering the deterioration in high resistance lamps to be a combined effect of heat and electricity, is more likely to be correct.

Dr. Fleming has called attention to the importance of homogeneity in the structure of the carbon, and here I fully agree with him. The thicker carbon is only, then, the more durable when it has the same homogeneity in structure as the thin carbon, otherwise it is likely to be destroyed much sooner. It is just here where the hollow carbon has, for obvious reasons, shown itself of enormous practical advantage.

Mr. Rawson has expressed the opinion that the carbons in the Bernstein lamp, which he had formerly seen, had not a very high emissivity, as he calls it, and he thinks the carbons now used may be better.

I hope they are better; but I should like to know how Mr. Rawson estimated the carbon as regards its power of emitting light and heat. I have often desired to make experiments upon this point, but there are enormous difficulties in the way, and opinions upon this question seem to differ very much. Mr. Mortimer Evans, Dr. Fleming, and Mr. Swinburne, have each expressed a different view. As for myself, I must confess that I think it very possible that the proportion of light and heat emitted at higher temperatures may differ with the nature of the substance, and of its surface; but this is merely an impression and not a conviction which is substantiated by facts. Mr. Evans lays great stress on the smooth surface of the radiating body. I think he is quite right to do so, but the advantage of the smooth surface may at the same time be in a direction different from the one which he indicated. I have lately made low resistance lamps—and in these lamps we have only to deal with the effects of heat, as the electric forces may be considered as nil—the carbons of which had a surface as smooth as a mirror, and I noticed that such carbons will withstand a much higher temperature without any evaporation than carbons with a rougher surface.

I cannot understand Mr. Crompton's objections to the explanation of the blue flame which I have given. Platinum absorbs very small quantities of oxygen but condenses enormous quantities of oxygen, a fact which is utilised to a great extent in practical chemistry. Further, the blue flame on the positive platinum is a flame and has nothing in common with fluorescence, which is a property of certain substances to which platinum certainly does not belong.

In reply to the question of Major-General Webber, I think that I have to correct one of the statements of my paper. I spoke of the platinum wire as being surrounded by the proper kind of glass, but I should have said, that the wires are imbedded in a special kind of enamel, which has the quality of adhering well to the platinum and of welding together with ordinary glass. If the receiver is made entirely of glass, it is quite impossible to use large currents in the lamps, but by making that part of the receiver, through which the wires pass, of enamel, this difficulty is overcome. The construction of the lamp, as far as the glass part is concerned, is the same as that of the ordinary Geissler tube.

I shall now turn to those remarks which have been made respecting the second part of my paper.

Mr. Mordey has called attention to the fact that hitherto glow lamps have been found to last longer when worked in parallel than in series, and Mr. Mordey has, at the same time, given the true explanation of this fact. Lamps which increase in resistance will gradually give less light with the same power when put in parallel, but they will thereby prolong their life. The reverse takes place if these same lamps are placed in series; they will then gradually give more light, and as the strain upon them is increased, their life will be shortened.

To give an example of the behaviour of a well known high resistance lamp in this respect, I mention from the results of the Committee of the Franklin Institute the behaviour of the Edison lamp No. 1.

The lamp requires in the beginning of the experiment 98·9 volts and ·69 ampère, giving a light of 15·3 candles, and it therefore requires 4·5 watts per candle.

After about 1,000 hours the candle-power has gone down to 7, and the power now absorbed is 8·7 watts per candle, or almost twice as much as in the beginning.

This example will sufficiently demonstrate the importance of using lamps which will not alter, both for the parallel as well as for the series system.

I hope very shortly to publish figures which will show the behaviour of the low resistance lamp in that respect, and I shall therefore abstain from making any further remarks upon that point for the present.

I cannot agree equally well with Mr. Mordey in his recommendation of a system in which a series of lamps placed in parallel is used. I think this arrangement can never be as satisfactory as a simple series system; and in a general system for the supply of electric light, the independence of every lamp must be considered as a *conditio sine qua non*. This does not exclude that several lamps may be turned off and on from a single switch in special cases.

One of the points in my paper, which seems to have elicited considerable comment, is the action of the cut-out and the fear of an interruption of the circuit, if such a cut-out should fail to act. As these cut-outs generally consist of an electro-magnet, which is placed in a shunt, and as the magnet has a very large margin of current to act in, I do not see why it should not act. A magnet is as sure to attract as the earth; the failure of telegraph instruments in this respect does not result from the failure of the magnets in their action, but from entirely different causes. I have used similar cut-outs for more than two years, and have never known one to fail.

But in order to satisfy those who are afraid of relying on the cut-out, I have lately added an arrangement which makes the interruption of the circuit a physical impossibility. For this purpose the wires which lead to the shunt coil are made sufficiently thick to carry the current of 10 ampères, and the coil is enclosed in asbestos paper. If the lamp gives out and the cut-out does not act, then the current in the shunt will gradually increase, the thin wire becomes heated, and the silk insulation carbonises. The consequence is that by-and-bye the shunt coil of high resistance transforms itself into a short conductor of large cross-section, which can carry the whole current. I have made the experiment several times, and always with the same result. It produces a disagreeable smell and smoke, but it is entirely devoid of danger; it should never happen, and if it does happen, can be stopped at once by the motion of the switch lever.

For additional safety there is an automatic cut-out connected with every house switch, so that the interruption of the current in one house by the cutting of a wire could not affect the other houses in the same circuit.

For large public buildings, such as, for instance, the British Museum, I would propose to supply the same by several circuits, of each of which only a small part of its E.M.F. is used in the building.

There is hardly any limit to the number of safety arrangements which may be used, although I feel convinced that they will prove superfluous

A great deal has been said about the uncertainty of electric light, but this uncertainty was merely the consequence of the small scale on which electric light plants were formerly made. The larger the scale, the greater the certainty in the supply; and if electric light plant is made only nearly as large as gas plant is usually made, then people will find that they can depend upon the supply of electric light just as much as on the supply of gas.

Before proceeding any further, I wish to make an experiment in order to demonstrate the action of the cut-out. For this purpose I shall now include a lamp with no vacuum in the circuit by moving the switch lever. [Does so. The light of the lamp increased until the carbon broke, when the cut-out acted and prevented any effect upon the other lamps.]

Here I may now answer a question of Mr. Rawson, who could not understand how incandescent lamps in series can be put in and taken out without danger when the current is passing through the circuit.

But he quite forgets that by turning the switch lever into position 1 [does so] I am disconnecting the wires leading to the lamp from the main line. Although there is a current of high potential passing through the main line, I can now take away the broken lamp, take hold of the bare ends of the wire with my hands [does so] and put in a new lamp without the possibility of coming in contact with the current. The system must therefore be considered absolutely safe in this respect, even if the main line should suffer from defective insulation.

I turn to the last point upon which I shall have to say a few words, viz., the application of high tension currents. I was very pleased to notice that some of the highest authorities in electric lighting in England have come to the conclusion that there has been much unjustified prejudice against the application of such currents.

The Board of Trade has at present fixed 200 volts as a limit of difference of potential which should be used inside a house. The idea of such limitation can only be that people may with impunity take hold of two bare conductors which have this difference of potential between them. But if 200 volts are the limits of safety for full grown men, then they must certainly be considered quite unsafe for children; and these require our protection more than grown up people. In fact, I would hardly undertake to say where the limit of safety would be under such circumstances. I have myself witnessed a case in which a strong man was knocked

down by a current, the E.M.F. of which could at no time exceed 50 volts. The effect produced upon him was evidently caused by a sudden change in the E.M.F. of the dynamo. Prof. Ayrton has already called attention to the fact that not the E.M.F. but the constancy of the current seems to be the main point as regards safety.

The determination of 200 volts as a limit was made in 1882, when we had but little experience in electric lighting, and the idea of fixing the limits of the E.M.F. was evidently derived from laboratory experiments, in which we are in the habit of handling bare terminals. But the conditions of actual lighting are very different from those of laboratory experiments. We have now four years more experience behind us for our guidance, and, looking towards the United States, where electric light occupies a far larger field than in England, we find that several thousands of circuits with high E.M.F. have been in operation for years. We have heard of accidents to attendants, which accidents might have been easily prevented by proper care; but we have never heard of any injury to those using the electric light, although the same is applied in shops, warehouses, and a great many inhabited places. This fact speaks very strongly in favour of high tension currents.

It may be asked what precautions should be adopted in case we make no limitation as regards the E.M.F. I think I have indicated the answer already in my paper. There are two conditions which should be fulfilled: first, the whole plant inside a house should be constructed in such a manner that no one can come in contact with any part conveying a current. In the second place, the electric light company which supplies the current must be made responsible for the maintenance of a certain insulation resistance.

If these two conditions are complied with electric light will be far safer than any other illuminant, whatever the E.M.F. of the current may be. As to the maximum E.M.F. of which we can avail ourselves, it will be regulated by our present means of insulation.

CORRESPONDENCE.

Incandescent Lamp Making.

If your correspondent, "Very Anxious," is known to us, we will have pleasure in sending him one of Alioth's voltmeters to try. They possess all the qualities he exacts of a voltmeter, namely, direct reading, immediate return to zero (no tapping being necessary) and no recalibration ever being necessary.

Heap & Stuart.

May 15*th*, 1886.

The inquiry of "Very Anxious," at page 460 of your last number, represents a desire for information as to incandescent lamp making which is very general. And even if it should prove that Mr. Edison is the only authorised manufacturer, it would still be interesting to know what determines a given candle power, with a given resistance of the filament. A contemporary of yours has lately contained remarkable answers on this subject.*

Besides the voltmeters named, there is Crompton's, and a new one by Statter; also one by Woodhouse and Rawson, which I believe to be pretty constant; but it is open to the objection that you have to use both hands to obtain a reading, and that the current must pass through in a specified direction. By the way, would "Very Anxious" say what process he prefers for "recalibrating" such instruments, and describe it?

Ajax.

May 15*th*, 1886.

Electric Repeaters for Railway Signals.

My attention has been directed to an article on "Electric Repeaters for Railway Signals," which appeared in your issue of the 23rd ultimo. Under this article it is stated that "Mr. Warwick, the late telegraph superintendent of the Midland Railway," was one of the first to apply electricity for this purpose.

Mr. Warwick was undoubtedly *one* of the first, but Mr. W. H. Preece, present electrician to the Post Office was *the* first to do so, and as the use of this form of electrical instrument is now becoming so general, it is but right that the credit of its first application should be correctly applied.

Mr. Preece's idea was to repeat by means of a miniature signal, the movement of the actual signal, placed out of the signalman's view, and this he effected, both as regards discs and semaphore signals.

W. Langdon.

Derby, *May* 12*th*, 1886.

How to wind Magnets.

Will you have the kindness as to tell me the meaning of the word "mils" in the interesting articles on "How to wind Magnets for shunt, series and compound machines," in your estimable journal. Do you express that for millimeters?

T. Bensdschuh.

11, Johannisbergstrasse, Magdeburg,
May 12*th*, 1886.

[The "mil" is the $\frac{1}{1000}$th part of an inch.—EDS. ELEC. REV.]

Earth Currents.

In testing some telephone lines lately, and wanting an earth connection, I used the ground wire of a "pole" for the same, but instead of getting an "earth" got a ("positive") current, which gave a good deflection on the galvanometer when put in circuit with any wire on the pole. The E.M.F. of the current would be about 2 volts, and remained constant. I tested several other poles in the vicinity, but without result. The pole in question is situated on an embankment composed chiefly of coal dust, &c.

I have often noticed very slight currents on long lines, but never anything like this. Perhaps some of the readers of the ELECTRICAL REVIEW can offer some solution to the above.

Sttawa.

17*th May*, 1886.

Schanschieff's Primary Battery.

I am somewhat surprised that no mention has been made in the ELECTRICAL REVIEW of Schanschieff's remarkable single fluid battery. A long and costly experience with primary batteries justifies me in saying that this is the most satisfactory and convenient yet invented. The liquid is an acid solution of sulphate of mercury, and from the sediment deposited by one gallon of it after use in a battery I recovered, by the simple process of squeezing through wash leather, 1 lb. 10 oz. of pure metallic mercury. The E.M.F. is quite constant until the solution is nearly exhausted, the reduction of the mercury being gradual and regular, while the zincs never need cleaning, being kept bright and well amalgamated by the action of the liquid.

G. Christopher Davies.

Norwich, *May* 15*th*, 1886.

[We have not yet had the pleasure of closely inspecting the battery mentioned, and we do not generally accept opinions on such matters as being beyond criticism unless accompanied by figures which cannot be gainsaid. We have at various times, and in a very forcible manner, expressed our views on the numberless primary batteries which have been devised to solve the problem of domestic electric lighting, and at no cost, but at an actual profit to the user. We should be glad if Mr. Davies would favour us with data respecting the performance of this battery, which from its constituent parts is doubtless about as good as primary batteries are made.—EDS. ELEC. REV.]

* *English Mechanic*, May 7th, page 222.